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LORENZ MÜLLER

1868–1953

1953 No. 3 **COPEIA** *August 26*

Lorenz Müller
1868–1953

SHORTLY before his 85th birthday Lorenz Müller succumbed to an unusually severe bronchitis, following upon a siege of grippe. In Lorenz Müller we buried a man who seemed to us younger colleagues to be a great stabilizing influence extending from a past era into our own restless times.

Lorenz Müller originally educated himself as a painter. He attended the Academy of Art in Munich, and finished his training in Paris, in Belgium and in the Netherlands. From his youth in Mainz, where he had kept and observed these creatures in his home, he had had a special love for amphibians and reptiles. After his return to Munich from his art studies abroad he entered into close relations with Oskar Boettger, Willy Wolterstorff, with amateur herpetologists in Munich like Karl Lankes, and with the zoologists and paleontologists of the University. At the urging of Franz Doflein, he devoted himself more and more to scientific illustration, and this brought him into closer and closer relations with the Munich Museum—the "Zoologische Sammlung des Bayerischen Staates." The herpetological division did not have a custodian; Müller took it under his wing, and from 1903 on he was voluntary curator. His activity as collector and his extremely successful negotiations for collections produced so great a growth of the division that in 1912 the Bavarian Landtag established a separate curatorship for it, and Lorenz Müller was the first to fill the new position.

The outbreak of World War I interrupted the connections with foreign correspondents, built up over many years. An air attack on Munich caused the first transfer of the collections, which were brought down from the third story of the "Alte Akademie" to the ground floor. From July, 1917 to the return of the army from the Balkan Peninsula in late 1918, Müller was a member of the Macedonian Geographic Commission (with the German Army), and during this period he made large collections of amphibians and reptiles and also of mammals and birds.

In 1928 Müller was made chief curator, and he remained active through his 66th year. He received the doctor's degree *honoris causa* from the University of Munich on the day of his retirement. His retirement did not mean a period of rest, for after a second transfer of the division, made possible by the quarters freed for the use of the museum by the building of the Zoological Institute, World War II again necessitated the evacuation of the greater part of the collection. This was carried out by Müller (brought back to active duty), and he was able to devote equal energy and care to the last transfer, after the war, from war storage to the provisional quarters in the Nymphenburg Palace. Only when he had reached his eightieth year did he again retire. Even in retirement, only extremely bad weather or his occasional bouts with respiratory illness kept him from his beloved desk and battery of terraria in the museum.

He had always maintained a special interest in the Mediterranean Region, in which he travelled repeatedly, almost always in the company of friends like Wolterstorff, Lankes, Kuliga, or Sellmayr. After he was 65 he returned to Bulgaria with Karl Lankes, collecting in the Plovdiv Region and in the Rhodope Mountains as far as the Grecian border.

Since the time of the travels of Spix and Martius in Brazil (as a part of the wedding entourage of the Princess of Bavaria) the Munich collections had been especially rich in South American material. Müller's active interest in this great fauna was especially stimulated by his own expedition to the Lower Amazon in 1909–1910. He made general collections for the Museum, learning to make a superb bird skin without a lesson. The subsequent expeditions of Hans Krieg, and collections received from a great variety of active field collaborators further increased these collections and gave rise to a long series of papers from Müller's pen.

Lorenz Müller's herpetological interests, however, were by no means limited to the Mediterranean and South American faunas. They

extended, in fact, to the world as a whole. After presenting his private collection of European amphibians and reptiles to the museum, he continued to add to it. This is now to be maintained as the *Lorenz Müller Collection*, and is to be further developed. He meticulously prepared all specimens received alive himself, and in this activity his vanity as collector and preparator was combined with the aesthetic pleasure of the artist in the variety of the forms of life.

Lorenz Müller's varied interests are reflected in more than 100 publications. His descriptions of new forms were usually supplemented by zoogeographic or evolutionary investigations, as of the Tyrrhenis problem in the Mediterranean, the explanation of melanotic forms, the characterization of the Chaco fauna, and the zoogeographic questions raised by the South American turtles. Early in his career he recognized the importance of individual and geographic variability; as result he insisted on the accumulation of large series, such as are scarcely to be found in any other European museum. These series are now contributing to studies on the origin of species and to the solution of problems of ecology and animal geography.

Far more significant than collections and scientific reports, or than the thousands of detailed letters to his correspondents, is the memory of Lorenz Müller's personality. His never-failing humor, his telling irony, his wealth of anecdote, and his love of his work made the deepest impression on all who knew him. He maintained the most active relations with collectors, donors, and fellow scientists throughout the world. His store of knowledge and the collection he had created drew colleagues to Munich from all parts of the world. His friendship with North American herpetologists was reflected in his being elected Honorary Foreign Member of the American Society of Ichthyologists and Herpetologists in 1948.

Even the heaviest blows of fate could not shake his character. During the bombing of Munich fire destroyed his house, and with it his invaluable library, unfinished manuscripts, his negatives, and the notebooks from his travels. Shortly before the end of the war an unusual double bomb explosion penetrated even to the subcellar in which they were stored to destroy his beloved lizard collections from the Balearic and Pityuse Islands. He refused to be cast down, and was ever capable of beginning afresh. His last efforts were devoted to the study of the European fire salamander, whose variability, inheritance, and distribution were being attacked by means of great newly accumulated collections, much of the material being received alive and kept alive for ontogenetic studies.

Though we have lost the mortal Lorenz Müller, his work, his stimulating energy, and the recollection of an extraordinary personality remain.—WALTER HELLMICH, *Zoologische Sammlung des Bayerischen Staates, Munich, Germany.* [Translation, courtesy Karl P. Schmidt.]

HAROLD LESTER BABCOCK

1886–1953

TO his fellow members of the American Society of Ichthyologists and Herpetologists outside of New England, possibly Dr. H. L. Babcock is best known for his handsome monograph "The Turtles of New England" (1919), a work which, with its many, beautifully executed, colored plates, has long since become a collector's item. While turtles always exerted a major attraction to Harold Babcock, being a born naturalist his keen and vivid interests embraced much wider aspects of animal and bird life, though most of his published writings dealt with reptiles and amphibians.

Babcock's contributions to COPEIA were mostly in the form of notes, with longer articles appearing in the Proceedings of the Zoological Society of London (of which he was

elected a Corresponding Member in 1930), the American Naturalist, New England Naturalist, Bulletin of the Antivenin Institute of America, Bulletin and also Occasional Papers of the Boston Society of Natural History (later the New England Museum of Natural History) for which Babcock wrote its first two guide books, namely "The Snakes of New England" (1929), and a "Field Guide to New England Turtles" (1938), in both of which every species was illustrated in color.

For the old Boston Society of Natural History (forerunner of the present Museum of Science), with which he was associated for more than a quarter century, Harold Babcock entertained a deep affection and served it loyally in a variety of capacities, viz.: Assistant Curator of Reptiles, 1920–26; Curator of Reptiles and Amphibians, 1926–46; Vice-President of the Society, 1939–44; Trustee, 1939–48; and Honorary Curator of Reptiles and Amphibians, 1946–1948. Dr. Babcock also took a great interest in the work of the Bermuda Biological Station of whose Corporation he was a Member.

Born May 30, 1886, at Holliston, Massachusetts, Harold Babcock attended Worcester Polytechnic Institute in 1905–06, and took his M.D. at Boston University School of Medicine in 1910. Following postgraduate studies in Europe he joined the staff of the Massachusetts Memorial Hospitals, becoming chief surgeon in otolaryngology and Professor of Otology at Boston University, positions he retained until reaching the retirement age a year or so ago. In his special field he was sought after as a consultant by a number of hospitals and maintained a private practice up to the beginning of the illness which caused his death on January 21, 1953.

His passing is greatly mourned by those of us privileged to be his friends, and our sympathy goes out to his widow, Mrs. Mildred Babcock, and his son Frank W. Babcock, and daughter Mrs. Constance Arthur, in their loss.—A. LOVERIDGE, *Museum of Comparative Zoology, Cambridge 38, Massachusetts.*

Fishes of the Family Gempylidae, with Records of *Nesiarchus* and *Epinnula* from the Western Atlantic and Descriptions of Two New Subspecies of *Epinnula orientalis*

MARION GREY

FISHES of the family Gempylidae are for the most part rarely caught and little known, and therefore the capture in the western Atlantic of several specimens each of *Nesiarchus nasutus* Johnson and *Epinnula orientalis* Gilchrist and von Bonde is worthy of note. The collections of the Chicago Natural History Museum (CNHM) contain six specimens of *N. nasutus* taken in deep-water hauls off Bermuda in 1948, and nine examples of *E. orientalis* taken in 1951 by the U. S. Fish and Wildlife Service research vessel OREGON in the Gulf of México.

Nesiarchus nasutus Johnson

Nesiarchus nasutus Johnson, 1862, Proc. Zool. Soc. London: 173, pl. 22; Steindachner, 1867, Sitz. K. Akad. Wiss., 56: 103, pl. 9; Capello, 1880, Jorn. Sci. Math. Phys. Nat. Lisboa, 2: 154; Günther, 1887, Rep. Sci. Res. Voy. Challenger, Zool., 22: 37; Holt and Byrne, 1909, Ann. Mag. Nat. Hist., (8) 3: 279; de Buen, 1917, Bol. Pesc. Inst. Esp. Oceanogr., 7–8: 57, fig.; 1935, Not. Res. Inst. Esp. Oceanogr., (2) 89: 99, pl. 23, fig. 45; Pellegrin, 1921, Bull. Soc. Zool. France, 46: 33; Roule, 1927, Bull. Inst. Océanogr. Monaco, 497: 9, fig.; 1935, Bull. Soc. Zool. France, 60: 439; Borodin, 1931, Bull. Mus. Comp. Zool., 72: 79; Nobre, 1935, Faun. Marin. Port., 1: 264, pl. 37, fig. 120; Forest and Legendre, 1950, Bull. Inst. Océanogr. Monaco, 966: 1.

Prometheus paradoxus Capello, 1867, Jorn. Sci. Math. Phys. Nat. Lisboa, 1: 260, pl. 4.

Thyrsitops violaceus Bean, 1887, Proc. U. S. Nat. Mus., 10: 513; Goode and Bean, 1895, Ocean. Ichthyol.: 195, fig. 209; Legendre, 1942, Bull. Soc. Zool. France, 67: 87.

Escolar violaceus Goode and Bean, 1895, Ocean. Ichthyol.: 519; Jordan and Evermann, 1898, Bull. U. S. Nat. Mus., 47 (3): 2843.

Bipinnula violacea Jordan and Evermann, 1896, *Ibid.*, 47 (1): 878; Sigalas, 1928, Proc.-Verb. Soc. Linn. Bordeaux, 80: 82.

MATERIAL.—Three specimens (481, 295 and 287 mm. standard length), CARYN haul No. 22, July 20, 1948, 32° 10.7′ N., 63° 32.5′ W., 2500 meters of wire out. One specimen (♂, 388 mm. standard length), CARYN haul No. 48, August 18, 1948, 32° 12.6′ N., 64° 36.2′ W., 1500 meters of wire out. One specimen (♀, 737 mm. standard length), CARYN haul No. 57, August 26, 1948, 32° 13.3′ N., 64° 37′ W., 2000 meters of wire out. One specimen (♂, 572.5 mm. standard length), CARYN haul No. 60, August 28, 1948, 32° 05′ N., 64° 38′ W., 1500 meters of wire out.

DESCRIPTION.—Dorsal XIX–XXI, 19–20 + 2–3. Anal 16–20 + 2–3. Vertebrae 34.

Measurements in hundredths of the standard length, for the type[1] and, in parentheses, for the six Bermuda specimens, in order of diminishing size: greatest depth 12.1 (10.4, 10.7, 10.2, 10.2, 9.85, 12.4), head 24.4 (24.6, 24.7, 28.6, 27.5, 32.4, 31.4), tip of snout to origin of dorsal 20.3 (20.7, 20.3, 23.6, 23.8, 26.2, 26.1), tip of snout to pectoral 22.2 (22.7, 22.9, 26.4, 25.8, 30.2, 29.0), tip of snout to ventral 24.8 (25.0, 24.8, 28.9, 28.6, 32.2, 31.2), tip of snout to origin of anal -- (78.0, 78.0, 78.5, 78.5, 77.6, 80.0, 78.5), diameter of eye 3.22 (3.2, 3.14, 3.95, 3.48, 4.15, 4.0), length of snout 10.2 (11.2, 10.8, 12.9, 12.6, 14.9, 14.6), interorbital width 3.48 (3.06, 3.14, 3.64, 3.72, 4.40, 3.84), length of upper jaw 11.3 (11.7, 11.3, 13.3, 13.4, 15.1 14.3), length of lower jaw, including tip 17.7, (17.1, 16.1, 18.5, 19.0, 20.7, 20.5), length of lower jaw process 2.0 (1.90, 1.57, 1.25, .77, 1.35, 1.74), length of postorbital -- (8.3, 8.75, 9.35, 10.0, 10.5, 10.3), length of pectoral fin 8.75 (7.9, 9.0, 10.0, 10.4, 11.9, 11.5), length of ventral fin 2.61 (2.58, 2.8, 3.12, 5.15, 4.07, 4.54), length of pre-anal spine 1.74 (1.83, 2.1, 2.7, 3.48, 2.38, 2.62), distance between pre-anal spine and vent 2.78 (3.12, 2.97, 2.92, 2.71, 2.88, 2.26), distance between vent and anal fin 3.92 (5.3, 4.37, 5.0, 5.15, 4.6, 4.2).

Measurements in hundredths of head length for the type and, in parentheses, from the six Bermuda specimens, in order of diminishing size: diameter of eye 13.2 (12.9, 12.7, 13.8, 12.7, 13.3, 12.8), length of snout 42.0 (45.4, 43.4, 45.0, 45.0, 47.0, 47.0), interorbital width 14.3 (12.4, 12.7, 13.6, 13.8, 12.4), length of upper jaw 46.5 (47.5, 46.0, 46.4, 47.0, 45.6) length of lower jaw including tip 73.4 (69.4, 65.0, 64.5, 67.5, 65.0, 65.7), postorbital length -- (33.5, 35.2, 32.6, 36.7, 33.0, 32.8).

The fangs in front of the upper jaw vary in number from three to six; they are slender, curved, and barbed at the tips; there are eight to twelve smaller premaxillary teeth on each side; the lower jaw has nine to fourteen teeth on each side; all teeth are somewhat deciduous, some with replacement teeth at their bases; none on palatines. Pyloric caeca 7.

When fresh, the color was as follows: head, back and sides dark purplish brown; belly dark silvery; fins dark brown; iris light brown; and inside of mouth dark brown.

DISCUSSION.—Forest and Legendre (1950) have shown that the genus *Escolar* Jordan and Evermann is a synonym of *Nesiarchus* Johnson, and they have also synonymized the western Atlantic *violaceus* with the eastern Atlantic *nasutus*. The material under consideration here supports their decision. In some of the Bermuda specimens the finlets are joined by small membranes either to the main body of the fin or to each other. There is also a slight separation between the two dorsal fins in our specimens, though not as wide as a fifth of the head length as described in *N. nasutus*. Except for the latter character and the slightly greater body depth of western Atlantic specimens, the two forms are in almost perfect agreement.

The six specimens at hand show that the head, snout, eye, jaws, pectorals and ventrals become relatively shorter during growth, and that the greatest body depth shifts from the region of the ventral fins (two smallest specimens) backward to past the middle of the body, below the fifteenth to eighteenth dorsal spines (two largest specimens). In the third specimen the greatest depth is below the seventh to twelfth dorsal spines; in the fourth it is below the origin of the first dorsal fin.

The two smallest examples possess two dagger-shaped spines in front of the anal fin, instead of the single spine found in larger specimens.

Since there are only three other records of this species from the western Atlantic[2] (the

[1] Measurements of type taken from Goode and Bean, 1895: 195.

[2] The Cuban record mentioned by Forest and Legendre is based on *Thyrsites niger* Poey, a species described from a fragment. Although Jordan and Evermann (1896: 878) included Poey's species in the synonymy of *Bipinnula violacea*, they stated in a footnote that the fish could not belong to the genera *Bipinnula* or *Thyrsitops* since the tail was keeled. *T. niger* is believed by Munro (1949) to be a possible synonym of *Lepidocybium flavobrunneum* (Smith).

type from Le Have Bank in 125 fathoms and two examples taken near Bermuda and in 37° N., 67° 12′ W., at depths of 1200 and 1500 meters), it was surprising to find these relatively large and active fishes in our nets on four different occasions; apparently they had entered in search of prey and were then unable to escape. All were taken at night in depths between about 270 and 480 fathoms, three in one haul, the others singly.

The stomach contents of the specimen from haul No. 48 included remains of a cuttlefish.

A large, living isopod was removed from one specimen (haul No. 48), and the two smaller specimens from haul No. 22 each had two ectoparasites (crustacean?) attached to various parts of the body. Parasitic worms were found in the liver, stomach and intestines of the three specimens examined internally by Dr. Lyell J. Thomas.

Epinnula orientalis americana, subsp. nov.

Epinnula orientalis Mead, 1951, COPEIA: 301.

TYPES.—Holotype, CNHM No. 46391, Oregon Station No. 265, 16 February 1951, 29° 20′ N., 87° 42′ W., 101 fathoms, standard length 220 mm. Paratypes, CNHM Nos. 46392–46393, Oregon Station No. 269, 17 February 1951, 29° 27.5′ N., 87° 26.5′ W., 150 fathoms, one specimen, standard length 163.5 mm.; Oregon Station No. 281, 25 February 1951, 29° 38′ N., 87° 16.5′ W., 112 fathoms, seven specimens, standard length 137.5–209.5 mm. All of the above stations are in the northern portion of the Gulf of México, on the hundred fathom curve off Pensacola and Mobile Bay.

DESCRIPTION.—Counts are given for the holotype, followed, in parentheses, by those of the paratypes. Dorsal XVI, I, 20 (XVI, I, 17–19). Anal III, 20 (III, 17–19). Pectoral 16 (15–16). Vertebrae 31, not including hypural.

Measurements in hundredths of the standard length, first for the holotype and, in parentheses, for the paratypes: head 30.3 (29.1–31.4); depth 22.7 (21.4–23.9); tip of snout to origin of dorsal 27.9 (23.6–26.9); tip of snout to origin of anal 68.7 (68.0–70.1); origin of anal to base of caudal 31.3 (30.6–33.2); tip of snout to origin of ventral 39.1 (38.6–41.4); base of ventral to vent 27.0 (26.2–29.6); upper angle of pectoral to origin of ventral 13.0 (12.8–14.1); length of caudal peduncle 10.9 (9.46–11.0); least depth of caudal peduncle 5.45 (5.25–5.8); longest dorsal spine 7.7 (6.9–10.5); snout 9.55 (9.45–10.3; orbit about 6.9 (6.7–7.95); interorbital 5.23 (5.21–6.1); length of pectoral 15.7 (14.9–17.4); length of ventral 9.55 (8.94–10.9).

Measurements in hundredths of the head lengths, for the holotype and paratypes as above: snout 31.3 (30.6–33.3); orbit about 22.5 (21.4–25.7); interorbital 17.2 (17.4–19.8); longest dorsal spine 25.0 (22.4–34.2).

Scales deciduous, only those along lateral lines remaining; in all specimens the upper lateral line terminates at the middle of the caudal peduncle, the lower one extending on one or two scales of the caudal base; holotype and two paratypes with the two lateral lines originating together at upper edge of gill-opening, remaining examples with the lower lateral line originating from the second or third scale of the upper one; shallow notch in opercular margin above pectoral fin; small opercular spine just below notch; interorbital region flattened, not as wide as diameter of orbit; fangs in front of upper jaw probably deciduous, varying in number from three to six, in some specimens several being smaller and softer in texture; other teeth in upper jaw small and widely spaced; teeth of lower jaw somewhat larger than those of upper, the two slightly enlarged ones at the tip fitting outside the upper jaw when the mouth is closed; one small tooth on each side of vomer, a single row on each palatine.

The series of specimens at hand suggests a growth-change similar to one of those found in *Nesiarchus nasutus*, i.e., a shift in the region of greatest depth. In three examples, 196–220 mm., the greatest depth is found at about the eighth dorsal spine; in the next four, 151–167 mm., it extends from the ventrals posteriorly for varying distances, in one case reaching a parallel from the vent; and in the two smallest specimens the greatest depth is at the ventral fins and extends only a short distance behind them.

COLOR.—Silvery; brownish on top of head, snout, tip of lower jaw and on back between upper lateral lines; spinous dorsal largely black; second dorsal, anal, caudal and pectoral dusky; ventrals light; bases of fins on some specimens yellowish; peritoneum and opercular linings dusky, inside the mouth somewhat so.

Epinnula orientalis pacifica, subsp. nov.

Epinnula orientalis Kamohara, 1938, Annot. Zool. Japon., 17: 48, pl. 3, fig. 4; 1938, Offshore Bottom Fish. Prov. Tosa: 20; 1942, Bull. Biogeogr. Soc. Jap., 12: 108; 1952, Rept. Kochi Univ., 3: 30, fig. 24; Herre, 1950, Philippine Jour. Sci., 79: 149.
Neoepinnula orientalis Matsubara and Iwai, 1952. Pacific Sci., 6: 193, figs. 1a, 2a, 5c.

TYPES.—Holotype, CNHM No. 59528, Japan, off Owase, Kumano-Nada, 15 March 1952, depth about 100 fathoms, standard length 183 mm. Paratype, CNHM No. 59529, same data, standard length 177 mm.

DESCRIPTION.—Dorsal XVI, I, 20 (paratype XVI, I, 19). Anal III, 20. Pectoral 14. Vertebrae 31, not including hypural.

Measurements of holotype (first) and paratype (second) in hundredths of the standard length: depth 22.7, 24.0; head 27.9, 28.5; tip of snout to origin of dorsal 27.6, 28.5; tip of snout to origin of anal 64.0, 66.4; origin of anal to base of caudal 33.1, 34.2; tip of snout to origin of ventral 36.3, 38.1; base of ventral to vent 28.2, 27.7; upper angle of pectoral to ventral origin 13.1, 13.5; length of caudal peduncle 12.1, 11.3; least depth of caudal peduncle 6.56, 6.79; longest dorsal spine 6.56, 7.63; snout 8.47, 9.04; orbit 5.73, 5.65; interorbital 6.29, 6.5; length of pectoral 12.8, 13.5; length of ventral 10.4, 10.1.

Measurements in hundredths of head length: snout 30.4, 31.7; orbit 20.3, 19.8; interorbital 22.6, 22.8; longest dorsal spine 23.5, 26.7.

COLOR.—Brownish or bluish gray, no trace of silver; spinous dorsal black, all other fins dusky; inside of mouth and gill-covers black.

DISCUSSION.—Comparison of Gulf of México and Japanese specimens shows that the Gulf form has a longer head, eye, snout and pectoral fin, a narrower interorbital space, a shorter and less deep caudal peduncle, and a greater distance between snout and anal origin and between snout and ventral origin. The interorbital width is not equal to the diameter of the orbit in *americana* and exceeds the same length in *pacifica*. The two forms also differ in color. (See key below.)

Although these differences may well be specific, it seems wise, in the absence of comparative material from other parts of the world, to treat them as subspecies of *E. orientalis* Gilchrist and von Bonde. In the typical form, known from only two specimens taken off South Africa, the ventral origin is more posterior than in either of the subspecies described here. The type description does not allow a comparison of proportions.

KEY TO GENERA AND SPECIES OF ADULT GEMPYLIDAE

1a. Lateral line faint or absent.
2a. Tail keeled; lateral line faint, undulate; dorsal spines 9–12; vertebrae 30–32. 1. **Lepidocybium** Gill
L. flavobrunneum (Smith)
2b. Tail not keeled; lateral line almost obsolete; dorsal spines 13–15; skin with bony tubercles.....2. **Ruvettus** Cocco
R. pretiosus Cocco

1b. Lateral line distinct.
3a. Snout and lower jaw without cartilaginous projections; palatine teeth present.
4a. Ventrals normally developed.
5a. Lateral line double.
6a. Upper lateral line running close to dorsal profile, the lower one running along ventral profile; dorsal spines 15–16..... 3. **Epinnula** Poey
7a. Lower lateral line commencing beneath base of 6th dorsal spine; no teeth on vomer.....*E. magistralis* Poey
7b. The two lateral lines originating together at upper edge of gill-opening, or the lower branching off from the 2nd or 3rd scale of the upper; vomer with 1–3 teeth on each side; vertebrae 31..... *E. orientalis* Gilchrist and von Bonde
8a. Ventral origin behind tip of pectoral.... *E. orientalis orientalis* Gilchrist and von Bonde
8b. Ventral origin beneath middle of pectoral.
9a. Interorbital space wider than diameter of eye; inside of mouth and gill-cover black.....*E. orientalis pacifica* subsp. nov.
9b. Interorbital space narrower than diameter of eye; inside of mouth mostly pale and of gill-cover dusky..... *E. orientalis americana*, subsp. nov.

6b. Upper lateral line running close to dorsal profile, the lower one on middle of sides; dorsal spines 17 ..... 4. **Thyrsitoides** Fowler
T. marleyi Fowler

5b. Lateral line single.

10a. Lateral line descending abruptly below posterior part of spinous dorsal; dorsal spines 20; vertebrae 37 ..... 5. **Thyrsites** Cuvier and Valenciennes
T. atun (Euphrasen)

10b. Lateral line nearly straight; dorsal spines 17 ..... 6. **Thyrsitops** Gill
T. lepidopoides (Cuvier and Valenciennes)

4b. Ventrals absent or reduced to a pair of spines.

11a. Lateral line double; dorsal spines 17–18; vertebrae 31 ..... 7. **Rexea** Waite
R. solandri (Cuvier and Valenciennes)

11b. Lateral line single.

12a. No large spine preceding anal fin; dorsal spines 18; vertebrae 33 (determined from dissection of a Japanese specimen) ..... 8. **Promethichthys** Gill
P. prometheus (Cuvier and Valenciennes)

12b. A relatively large free dagger-shaped spine preceding anal fin; dorsal spines 20–21 .....
.....9. **Nealotus** Johnson
N. tripes Johnson

3b. Snout and lower jaw with conical cartilaginous processes, those of the lower jaw much the larger; no teeth on palatines.

13a. Lateral line single; dorsal spines 20–21; vertebrae 34 ..... 10. **Nesiarchus** Johnson
N. nasutus Johnson

13b. Lateral line double.

14a. Descent of lower lateral line abrupt; dorsal spines 18 ..... 11. **Mimasea** Kamohara
M. taeniosoma Kamohara

14b. Descent of lower lateral line gradual; dorsal spines 29–32; vertebrae 53 .....
.....12. **Gempylus** Cuvier and Valenciennes
G. serpens Cuvier and Valenciennes

The key offered above has been prepared largely through use of the literature published on the Gempylidae. The collections of the Chicago Natural History Museum contain only the following genera: *Ruvettus*, *Epinnula*, *Promethichthys*, *Rexea*, *Nesiarchus* and *Gempylus*. The genera show, in general, a trend from the more orthodox scombroid form represented by *Lepidocybium* toward the long compressed body of *Gempylus*, which approaches the body form of the Trichiuridae. There is a puzzling scattering of such characters as the presence of a free dagger-shaped spine preceding the anal fin, of dorsal and anal finlets, double or single lateral lines; and the presence, absence, or reduction of ventral fins.

Gempylus, *Nesiarchus* and *Mimasea* have several characters in common, especially the elongate, compressed body and the conical cartilaginous processes on snout and lower jaw, those of the latter much the larger in all three genera. Further close relationship, and distinction from all other genera, is indicated by their lack of palatine teeth.

Double lateral lines are found in *Gemyplus* and *Mimasea* but not in *Nesiarchus*. Most authors have assumed the presence of only one lateral line in *Gempylus*, although Cuvier and Valenciennes (1831: 152) described on the type of *serpens* a second one close to the base of the dorsal fin. Their work included a figure of *coluber* (since synonymized with *serpens*) but not of *serpens*, and the upper lateral line does not appear on this figure. Several examples, both from the Atlantic and Pacific oceans, have been examined by Mr. Loren P. Woods and were found to possess this upper lateral line, which terminates below the end of the second dorsal fin, and Matsubara and Iwai (1952) described two lateral lines.

The presence of dorsal and anal finlets has been purposely omitted from the key because in some cases these are difficult to distinguish from the main body of the fins.

Juvenile Specimens

One of the outstanding characteristics of some young gempylids is the presence of one or two relatively large, free spines just anterior to the anal fin. Two genera retain a single spine as

adults (*Nealotus, Nesiarchus*). Young *Nesiarchus* possess two of these spines, the second one smaller, and these are also present in young specimens of *Gempylus*, although they are absent in the adult of that genus. An examination of Japanese and Hawaiian specimens shows that *Promethichthys* also possesses two free spines preceding the anal fin, but in this genus they are relatively minute. Matsubara and Iwai (1952) have noted the presence of a second, minute spine preceding the anal fin in *Nealotus*, and Matsubara (*in litt.*, 1952) reported two minute spines in *Mimasea*, which, however, are not free from the anal fin.

The genus *Dicrotus* Günther was based on a juvenile specimen later suspected by Johnson (1865: 436) to be the young of *Promethicthhys prometheus*. Johnson recorded a similar but larger example showing further development toward the adult of *P. prometheus*. Lütken (1880: 456, pl. 3, figs. 3–8) described several young gempylids, one series of which he referred to *Nealotus tripes*, the other to *Gempylus serpens*. He also upheld the opinion that *Dicrotus armatus* Günther is the young *P. prometheus*. The adult of *Dicrotus parvipinnis* Goode and Bean is not known.

The identification of the 5–10 mm. specimens referred to by Günther (1889: 7, pl. 1, figs, C, D) as *Thyrsites prometheus* must remain somewhat doubtful, since *prometheus* has only 18 dorsal spines whereas Günther recorded 20 spines for these larvae. Also in doubt is the identification with *prometheus* by Roule and Angel (1930: 92, figs. 115, 116) of two small specimens from the Atlantic. The largest of these also has 20 dorsal spines. Regan (1916: 144, pl. 8, figs. 1–3) recorded juveniles 5–10 mm. long as *Thyrsites atun*.

Distribution

Lepidocybium flavobrunneum (Smith) has been fully discussed by Munro (1949), who stated that the correct distribution includes waters off Madeira, Cape Point (South Africa), Japan, Hawaii, New South Wales, Lord Howe Island, California, Perú, and, tentatively, Cuba (*Thyrsites niger* Poey). Length, 460–1220 mm.

Ruvettus pretiosus Cocco. Only a comparative study of the several described species will determine whether or not all are synonymous. The distribution of the genus includes the Mediterranean; the eastern Atlantic, from Cardiff, Wales to South Africa; the western Atlantic, from Newfoundland to the West Indies; and the Pacific from California, Hawaii, the South Sea Islands from Paumotu (ca. 140° W., 16° S.) to Nissan of the Charles Hardy Group (ca. 154° E., 4° S.), New Zealand, Australia, the East Indies and Japan. Length, 240–2000 mm.

Epinnula magistralis Poey is known from two specimens taken in the western Atlantic (Cuba, Caribbean) and three from Japan. The latter have several more anal and soft dorsal rays than do the Atlantic specimens, and probably represent a distinct species or subspecies. The larger eye, somewhat greater body depth and longer ventral fins of the Japanese examples might possibly be explained by their smaller size. Poey's type measured 980 mm., the Albatross specimen over 500 mm., while the three known from Japan were 242, 285 and 277 mm.

Epinnula orientalis Gilchrist and von Bonde has been taken off South Africa, in the Gulf of México, and, in the Pacific, off Japan and the Philippines. Length, 130–260 mm.

Thyrsitoides marleyi Fowler is known only from the type, taken off Durban, South Africa, and a specimen from off East London, South Africa. Length, 590–1280 mm.

Thyrsites atun (Euphrasen) is found in the southern parts of the Atlantic (South Africa, Tristan da Cunha, Argentina) and Pacific (Chile, New Zealand, Australia) and north to the East Indies. Length, about 500–1400 mm.

Thyrsitops lepidopoides (Cuvier and Valenciennes) is found off the coasts of South America from Brazil to Chile. Length, 270–300 mm.

Rexea solandri (Cuvier and Valenciennes) is known from the tropical Indian Ocean and, in the western Pacific, from Japan to New Zealand. Length, 100–785 mm.

Promethichthys prometheus (Cuvier and Valenciennes) has been found off Madeira, the Azores, the Canaries, Bermuda, St. Helena and Ascension Islands in the Atlantic; Hawaii, Japan, the Philippines and various south sea islands in the Pacific. Length, 50–608 mm.

Nealotus tripes Johnson was described from Madeira and has also been reported from the Gulf of Guinea, the south Atlantic, off Bermuda, and off Japan. Length, 33–253 mm.

Nesiarchus nasutus Johnson is a north

Atlantic species known in the east from Ireland to the Canary Islands and in the west off Nova Scotia and near Bermuda. Length, 287–1260 mm.

Mimasea taeniosoma Kamohara. Known only from Japan. Length, 322–422 mm.

Gempylus serpens Cuvier and Valenciennes is widely distributed in all tropical seas, although there is only one record from the Indian Ocean (off East London, South Africa). It is generally conceded that all described forms belong to one species. Length 445–1000 mm., young to 88 mm.

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Geographic and Systematic Status of the Fishes Described by Kner and Steindachner in 1863 and 1865 from Fresh Waters in Panamá and Ecuador[1]

Carl L. Hubbs

In this paper I attempt to clarify the localities and the identifications of the fishes that Kner and Steindachner described in 1863 and 1865 from fresh waters in Panamá and Ecuador, on the basis of the pioneering collections of zoogeographer Moritz Wagner.

Chief reference has been made to their main report, the date of which is ordinarily given as 1864, but is listed in Dean's *Bibliography of Fishes* (1, 1916: 694) as 1870. It is here assumed to be 1865, in accordance with the remark by Günther (1866: 173), "although this memoir is dated 1864, its publication appears to have been delayed to 1865, and it could not be obtained through booksellers before 1866."

As Günther noted, the new species differentiated by Kner and Steindachner (18, not 17) were first characterized in the Sitzungsberichte of the Bavarian Academy for 1863. That paper is not listed in Dean's *Bibliography of Fishes* and has apparently seldom been consulted. This preliminary contribution was presented by von Siebold but is definitely accredited to Rudolf Kner. The species should be attributed to Kner and Steindachner, however, for Kner stated (p. 221):

> Hoch erfreut und geschmeichelt durch diese ehrenvolle Aufforderung, unternahm ich in Vereine mit meinen jungen Freunde F. Steindachner, Adjunkten am Kais. Hof-Naturalienkabinete die Lösung dieser Aufgabe.

The original diagnoses are acceptably given in Latin, with comparative notes in German.

As Günther also noted, the main report by Kner and Steindachner was followed by a geographical and ecological treatise, by Wagner

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 610.

(1865), based on the same collection. It would appear that this report also has been little used.

One source of confusion regarding localities has stemmed from Kner and Steindachner's use of "Neu-Granada." In their time Nueva Granada was equivalent to Colombia and included Panamá (earlier the viceroyalty of Nueva Granada covered northwestern South America, including Venezuela and Ecuador as well). That all of Kner and Stendachner's "Neu-Granada" localities are ascribable to Panamá was made clear by Wagner (1865: 90, footnote 1) in the following generally overlooked statement:

> Nach diesen genaueren Angaben des Vorkommens sind einige kleine Irrthümer, die sich in die vorhergehende Abhandlung der Herren Kner und Steindachner hinsichtlich der Fundorte eingeschlichen haben, zu berichtigen. Wo dort "Neu-Granada" als Fundort genannt wird, ist immer der Isthmusstaat Panama gemeint, der zum Gebiet der Republik Neu-Granada gehört.

The species treated by Kner and Steindachner may now be considered in systematic order.

Squalidae

?*Squalus cubensis* Howell Rivero, 1936

Acanthias vulgaris, Risso?—Kner and Steindachner (in Kner, 1863: 230), "Panama, Nordseite."—This record has obviously been the basis for the inclusion of "Panama" in the range of species of *Squalus* (= *Acanthias*). It was entered by Günther (1868: 396) in his distributional table, where the species *Acanthias vulgaris* is listed as marine from "*Atl., Ind., & Pac. Oceans* (Panama)." Wagner (1865: 90) wrote that he took the species in brackish water in stream mouths on both sides of the Isthmus. Kner and Steindachner, however, listed only one specimen and specified "Nordzeite." Since Wagner was rather careless in his listings, the record from the Pacific may be regarded as erroneous and we may doubt that the "Nordseite" specimen came from brackish water. We may, therefore, disregard the Pacific Panamá records of "*Squalus sucklii* (Girard)," by Gilbert and Starks (1904: 13) and of *Squalus* (species not identified), by Meek and Hildebrand (1923: 64–65). It seems probable, however, that Wagner did collect a *Squalus* on the Atlantic side of Panamá. It may well have been a specimen of *Squalus cubensis* Howell Rivero, which is known definitely from Cuba and probably from Trinidad and Brazil (Bigelow and Schroeder, 1948: 473–78).

Engraulidae

Lycengraulis poeyi (Kner and Steindachner, 1863)

Engraulis Poeyi, n.—Kner and Steindachner (in Kner, 1863: 224; 1865; 23–24, pl. 3, fig. 3), "Rio Bayano, Panama."—The original diagnosis of this species has consistently been overlooked.

Anchovia macrolepidota (Kner and Steindachner, 1863)

Engraulis macrolepidota, n.—Kner and Steindachner (in Kner, 1863: 224; 1865: 21–23, pl. 3, fig. 2), "Rio Bayano, Panama."—The original diagnosis of this well-known species, also, has consistently been overlooked.

Characidae

Saccodon wagneri Kner and Steindachner, 1863

Saccodon Wagneri, n.—Kner and Steindachner (in Kner, 1863: 225; 1865: 31–35, pl. 4, fig. 2), "aus dem Staate Ecuador" (1863); "Ecuador" (1865).—The original diagnosis of this endemic characin has been overlooked, as by Eigenmann (1922: 112), though the standard nomenclators refer to the 1863 naming of the genus. Wagner (1865: 34) indicated that the species lives in the middle region of the streams on the west side of the Andes, between 1,000 and 6,000 feet elevation.

Brycon atricaudatus (Kner and Steindachner, 1863)

Chalceus atricaudatus, n.—Kner and Steindachner (in Kner, 1863: 227; 1865: 44–47, pl. 4, fig. 3), "von Westabhange der Andes im Staate Ecuador."—This species has wrongly been accredited, as by Eigenmann (1922: 131) to Kner alone.

Brycon striatulus (Kner and Steindachner, 1863)

Chalcinopsis striatulus, n.—Kner and Steindachner (in Kner, 1863: 226; 1865: 38–41, pl.

5, fig. 2), "Panama" (1863); "Neu-Granada [properly, Panamá] und Panama an der Seite des stillen Ocean" (1865).—For some reason this species and the next have also consistently been attributed to Kner alone. These two forms were long synonymized, but have been treated as distinct in more recent reviews (Meek and Hildebrand, 1916: 293–99; Eigenmann, 1922: 129–39; Hildebrand, 1938: 274–86). Perhaps having both species in mind, Wagner (1865: 90) stated that *Chalcinopsis striatulus* occurs in the middle section of the streams on both watersheds.

Brycon chagrensis (Kner and Steindachner, 1863)

Chalcinopsis chagrensis, n.—Kner and Steindachner (in Kner, 1863: 226; 1865: 42–43, pl. 5, fig. 3), "Rio Chagres an der Nordseite von Panama."—This species has passed through the same nomenclatorial history as the last. The specific name in their synonymic reference was misspelled *chagresensis* by Jordan and Evermann (1896: 337).

Pseudochalceus lineatus Kner and Steindachner, 1863

Pseudochalceus lineatus, n.—Kner and Steindachner (in Kner, 1863: 225–26; 1865: 35–38, pl. 5, fig. 1), "vom Westabhange der Anden im Staate Ecuador."—This species has been accredited wrongly to Kner alone, as by Eigenmann (1921: 227; 1922: 140), who, furthermore, wrongly quoted Wagner as stating that it occurs only at about 1,000 feet elevation. Wagner wrote that it lives on the western slope of the Andes at elevations between 1,000 and 6,000 feet.

Astyanax sp.

Tetragonopterus aeneus Günth.—Kner and Steindachner (in Kner, 1863: 229; 1865: 46), "Rio Chagres."—*Tetragonopterus Gronovii* C. V.—Kner and Steindachner (in Kner, 1863: 229; 1865: 46–47), "Rio Bayano."—Since the species of *Astyanax* in Panamá are distinguished chiefly by color (Meek and Hildebrand, 1916: 280–82; Eigenmann, 1921: 227–310; 1922: 142–45; Eigenmann and Myers, 1929: 541–42; Hildebrand, 1938: 257–64), and are still of uncertain status, and since Kner and Steindachner described their material very briefly, with no color notes, I venture no specific identification of their specimens, allegedly of two species. Wagner (1865: 90), carelessly, I presume, attributed both species to both watersheds.

Hoplias microlepis (Günther, 1860)

Macrodon (*Erythrinus*) *brasiliensis* (Spix) or *Macrodon fasciatus* ("ist fraglich, vielleicht doch neue Art und dann also Macrod. fasciatus zu bezeichnen").—Kner and Steindachner (in Kner, 1863: 229), "aus Neu-Granada und dem Rio Chagres."—This case poses a nomenclatorial problem. In the 1863 account there is no trace of description, merely the name, locality, specimen numbers, and the statement quoted above regarding the new designation to be applied if, possibly, the form should be distinct. In the 1865 account, under the heading "Gattung: **Macrodon**, J. Müll.," Kner and Steindachner discussed the characters of the Panamá specimens and compared them with accounts of several species, but did not arrive at a specific identification. In this discussion they made no reference to the name *fasciatus*. Nor, so far as apparent, has any other ichthyologist taken cognizance of this name, which, presumably, can be regarded as a *nomen nudum*. If, on the basis of the expanded treatment of 1865, it should be thought that the name is available, the case should be submitted to the International Commission on Zoological Nomenclature for such action as might be needed to suppress the name. I select "Chagres River" as the type locality of *Macrodon microlepis* Günther (1864: 282) and thus make it the precise equivalent of *Macrodon fasciatus*. Günther, by slip, gave the range of *microlepis* as "Western Ecuador; Guatemala," for he listed specimens only from "Western Ecuador" and "Chagres River." The latter were extant in 1908, when they were included by Regan (1908: 167) as "the types of the species" in his redescription of *Hoplias microlepis*. The status of the form was discussed by Meek and Hildebrand (1916: 303–05), Eigenmann (1922: 169–70), and Hildebrand (1938: 289–90). Wagner (1865: 90) listed "*Macrodon brasiliensis?* Spix" from both watersheds of the Isthmus.

GYMNOTIDAE

Sternopygus macrurus (Bloch and Schneider, 1801)

Sternopygus macrourus Mll. Tr.—Kner and Steindachner (in Kner, 1863: 230), "Rio Guajaquil in Ecuador."—This locality for the wide-ranging species was verified by Eigenmann (1922: 172–73).

ARIIDAE

Arius multiradiatus Günther, 1864

Bagrus ? *arioides*, n.—Kner and Steindachner (in Kner, 1863: 227; 1865: 47–49), "Rio Bayano im Staate Panama, Südseite."—On the synonymy of this species, consult Meek and Hildebrand (1925: 123).

PIMELODIDAE

Rhamdia wagneri (Günther, 1868)

Pimelodus cinerascens Günth.—Kner and Steindachner (in Kner, 1863: 229; 1865: 49–52), "Neu-Granada" (1863); "Rio Chagres, Guajaquil [see next species] und Neu-Granada [properly, Panamá]" (1865).—Meek and Hildebrand (1916: 240) referred the Panamá records to *R. wagneri*. Wagner (1865: 90) reported "*Pimelodus cinerascens*" from both watersheds of the Isthmus.

Rhamdia cinerascens Günther, 1860

Pimelodus cinerascens Günth.—Kner and Steindachner (in Kner, 1863: 229; 1865: 52), "Guajaquil" material only.—Since *cinerascens* was described by Günther (1860: 237, pl. 10, fig. A) from "fresh waters of Guayaquil and Esmeraldas," and since I here designate Guayaquil as the type locality, the "Guajaquil" record by Kner and Steindachner may be regarded as correctly identified.

? *Pimelodella chagresi* (Steindachner, 1876)

Pimelodus modestus Günth.—Kner and Steindachner (in Kner, 1863: 229; 1865: 49), "Rio Chagres."—Regan (1907: 137) has suggested that this record of *modestus*, unaccompanied by a description, was not improbably based on *P. chagresi*.

ASTROBLEPIDAE

Astroblepus grixalvii von Humboldt

Brontes prenadilla C. V.—Kner and Steindachner (in Kner, 1863: 230), "Cotopaxi."—This specimen was a topotype of *Brontes prenadilla* Valenciennes, which Eigenmann (1922: 53) synonymized with *Astroblepus grixalvii* von Humboldt.

TRICHOMYCTERIDAE

Trichomycterus laticeps Kner and Steindachner, 1863

Trichomycterus laticeps, n.—Kner and Steindachner (in Kner, 1863: 228; 1865: 54–56, pl. 6, fig. 2), "Fundort, wie die vorige Art [*T. taenia*]."—This form has wrongly been accredited to Kner alone, as by Eigenmann (1918: 307; 1922: 60).

Tchernavin (1944: 244–45), taking violent issue with Eigenmann and Eigenmann (1890: 325; quoted by Eigenmann, 1909: 247–48), gave seemingly valid reasons for rejecting the name *Pygidium* for this genus and entered a strong plea for returning to *Trichomycterus*. The name "*thrichomycterus*" as proposed by von Humboldt (quoted by Eigenmann, 1918: 341) may be interpreted as a vernacular and, therefore, as having no standing. *Trichomycterus* Valenciennes would then surely be valid. Under the complicated circumstances, however, it may require a special decision of the International Commission on Zoological Nomenclature to restore validly the name *Trichomycterus*.

Trichomycterus taenia Kner and Steindachner, 1863

Trichomycterus taenia, n.—Kner and Steindachner (in Kner, 1863: 228; 1865: 52–54, pl. 6, fig. 1), "vom Westabhange der Andes im Staate Ecuador."—This is another species that has been accredited to Kner alone, as by Eigenmann (1918: 310; 1922: 61). Since Kner and Steindachner used the form *taenia* in conjunction with a genus of masculine gender it is obvious that they employed a noun, which is not to be declined (as Eigenmann did in the combination *Pygidium taenium*).

LORICARIIDAE

Plecostomus plecostomus panamensis Eigenmann, 1922

Hypostomus plecostomus? C. V.—Kner and Steindachner (in Kner, 1863: 230; 1865: 60–61), "Neu-Granada [properly, Panamá]."—

Eigenmann (1922: 69) referred Kner and Steindachner's account to the synonymy of his new subspecies, *panamensis*.

Ancistrus chagresi Eigenmann and Eigenmann, 1889

Ancistrus (*Hypostomus*) *cirrhosus* Kn.—Kner and Steindachner (in Kner, 1863: 229; 1865: 60–61), "Rio Chagres."—Meek and Hildebrand (1916: 251) referred Kner and Steindachner's account to the synonymy of *A. chagresi*.

Loricaria uracantha Kner and Steindachner, 1863

Loricaria uracantha, n.—Kner and Steindachner (in Kner, 1863: 228–29; 1865: 56–58, pl. 6, fig. 3), "aus dem Rio Chagres, Nordseite von Panama" (1863); "aus Neu-Granada [properly, Panamá] und dem Rio Chagres" (1865).—Apparently on the basis of Wagner's (1865: 90) probably careless and incorrect statement, Günther (1868: 393, 478), Eigenmann (1910: 413), and others reported this species on both slopes of the Isthmus. As the result of their surveys Meek and Hildebrand (1916: 257) and Hildebrand (1938: 241) doubted the Pacific drainage reports.

A second species "aus dem Rio Chagres" was identified by Kner and Steindachner (1863: 229; 1865: 58–60) with *Loricaria lima* Kner, 1853. Wagner (1865: 90) and Günther (1868: 393) attributed it also to both watersheds of the Isthmus, likely in error. Eigenmann and Eigenmann (1891: 39) and Jordan and Evermann (1896: 158) accepted the Panamá record, but Meek and Hildebrand ignored it. Regan (1907: 113) referred Kner and Steindachner's *L. lima* to *L. uracantha*.

POECILIIDAE

Mollienisia sphenops gilli (Kner and Steindachner, 1863)

Xiphophorus Gillii.—Kner and Steindachner (in Kner, 1863: 224; 1865: 25–28, pl. 4, fig. 1), "Rio Chagres."—The original and adequate diagnosis of this form has been missed by subsequent authors.

The name *gilli* is certainly applicable to a Panamá subspecies of *M. sphenops*. It is the oldest name available for any subspecies from south of México. The type locality may be designated as the middle reaches of Río Chagres. This river is the only one mentioned by Kner and Steindachner in either paper, though Wagner (1865: 90) attributed the species to both watersheds of the Isthmus. Wagner included it among those he had collected "in süssen Wasser des mittleren Flusslaufes."

The distinctiveness of the middle-Chagres form of *M. sphenops* is indicated by an examination of numerous specimens from the river itself and from the large reservoir (Lake Chagres) in its course. The genetic validity of the characters has been confirmed by extensive breeding experiments in which this subspecies was utilized along with several others. *M. s. gilli* may be distinguished by the following characterization. The size is generally small to moderate and males often mature when very small. Higher males have the body and caudal peduncle moderately deep and the dorsal fin often greatly elongated, at times considerably overlapping the basal part of the caudal fin. The dorsal base, however, is short, for the fin has 7 to 10, usually 9 rays, counting all elements, the last pair as one (in several topotypic series I have counted 7 dorsal rays in 1 specimen, 8 in 44, 9 in 114, 10 in 1). In young females and in low males the basal part of the dorsal is more or less blackened. Males have rather faint vertical bars and both males and females have rows of faint spots. The gonopodium usually retains, more or less well developed, the membranous hook at the tip of ray 3, but the retrorse segment at the tip of ray 5p is variably weakened. There is no mustache. The teeth of the inner bands of the jaws are strictly unicuspid. These bands are unusually narrow (only 2 to 4 teeth wide), slightly curved medially, incurved toward the rather wide median separation. Each premaxillary band is sharply recurved backward and inward from its outer end. There is almost no backward projection from the outer end of the mandibular band. The lower margin of the preorbital, which turns upward just behind the lowest preorbital pore, is usually more or less completely bound down by a thin, easily ruptured membrane, and one or more of the 3 preorbital pores are commonly covered by membrane.

?Agonostomus monticola (Bancroft, 1836)

Dajaus elongatus, n.—Kner and Steindachner (in Kner, 1863: 222; 1865: 6–9, pl. 1, fig. 2), "Panama" (1863) or "Neu-Granada [properly, Panamá]" (1865).—This nominal species was, oddly, overlooked by Jordan and Evermann (1896: 819–20), Regan (1907: 66–69), Meek and Hildebrand (1916: 333–36), and Hildebrand (1938: 322–24), although it was treated by Günther (1866: 192; 1868: 444–45) as a synonym of his own *Agonostoma nasutum*. On the basis of the revision by Regan one might concur with Günther's identification, but the genus *Agonostomus* is in great need of revision. Meek and Hildebrand (1916: 334–35) regarded *A. nasutus* as a synonym of *A. monticola*, placing no reliance on the thickness or shape of the lip. Pending further study, I accept their judgment.

Kner and Steindachner (in Kner, 1863: 229; 1865: 8–9) separated two other species, *Dajaus monticola* from "Neu-Granada" (properly, Panamá) and *D. nasutus* ("von der Westküste Panamas"). Of the authors quoted in the last paragraph only Günther took cognizance of these records. He referred Kner and Steindachner's *D. nasutus* to *Agonostoma nasutum*, but accepted the specific identification of their *D. monticola*. Their *D. monticola*, however, would probably also be *Agonostomus nasutus*, if valid, because they describe their "Neu-Granada" specimen as having the snout blunter and more convex toward the tip than in the two other species.

Wagner (1865: 89–90) indicated, perhaps loosely, that he had caught all three nominal species in the brackish water of stream mouths on both sides of the Isthmus.

HAEMULIDAE

Pomadasys bayanus Jordan and Evermann, 1898

Pristipoma humile, n.—Kner and Steindachner (in Kner, 1863: 221–22; 1865: 3–5, pl. 1, fig. 1), "Rio Bayano, Staat Panama, Südseite."—Jordan and Evermann (1898: 1331) replaced Kner and Steindachner's preoccupied name with *Pomadasis bayanus*. As Meek and Hildebrand (1925) indicated, the original as well as the classically correct spelling of the generic name is *Pomadasys*.

CICHLIDAE

Aequidens coeruleopunctatus (Kner and Steindachner, 1863)

Acara coeruleopunctata, n.—Kner and Steindachner (in Kner, 1863: 222–23; 1865: 16–18, pl. 2, fig. 3), "Rio Chagres im Staate Panama, Nordseite" (1863); "aus dem Rio Chagres und von westlichen Gehänge der Andes" (1865).—This species has been correctly cited, except in that Jordan and Evermann (1898: 1514) accredited Salvin as the collector of the types. Wagner (1865: 90) indicated that he had taken the species in the middle course of streams on both watersheds of the Isthmus, possibly referring to the record from the western slope of the Andes. Eigenmann (1922: 197), however, doubted the occurrence of this cichlid in northwestern Ecuador.

Cichlasoma altifrons (Kner and Steindachner, 1863)

Heros altifrons, n.—Kner and Steindachner (in Kner, 1863: 223; 1865: 11–13, pl. 2, fig. 1), "Panama" (1863); "Neu-Granada [properly, Panamá]" (1865).—This species was omitted by Meek and Hildebrand (1916), because, according to Hildebrand (1938: 328–29), "of the uncertainty regarding the type locality." This doubt might have been dispelled had they checked the original description, and certainly would have been eliminated, had they read Wagner's (1865: 90) statement that this "ausgezeichnete Art findet sich weder im Rio Bayano, noch im Rio Grande der Südseite, sondern ausschliesslich nur in den südlichen Flüssen des Department Chiriqui (West-Veragua)." Günther (1868: 391, 459) and Eigenmann (1910: 475) repeated this type locality, which has been verified by Behre (1928: 321). We may now negate the statement (Jordan and Evermann, 1898: 1538) that *altifrons* ranges southward beyond the Isthmus of Panamá and deny the allocation of the species to Colombia (in modern limits) by Regan (1905: 243; 1906: 25) and by Hildebrand (1938: 329). It was not attributed to that country by Eigenmann (1922: 203–04). Since *C. altifrons* appears to occupy the adjacent parts of the Pacific drainage of Panamá and Costa Rica, there is no reason to accept Hildebrand's characterization of its range as peculiar.

Paraneetroplus sieboldi (Kner and Steindachner, 1863)

Heros Sieboldii, n.—Kner and Steindachner (in Kner, 1863: 223; 1865: 13–15, pl. 2, fig. 2), "Panama an der Südseeseite" (1863); "Neu-Granada [properly, Panamá] und vom westlichen Abhange der Panama-Landenge" (1865).—Meek and Hildebrand (1916: 346) and Hildebrand (1938: 336–37) commented on their failure to find this species in Panamá and again confounded "Neu-Granada" with Colombia in the modern sense. This species was attributed to Colombia also by Regan (1905: 235; 1906: 30), and by Eigenmann (1910: 474) once, though he properly excluded it from his 1922 monograph on the fishes of northwestern South America. It probably has a distribution like that of *Cichlasoma altifrons*, on the Pacific slope in the Chiriqui province of Panamá and in Costa Rica. In this regard I agree provisionally with the synonymies of Regan (1908: 186) and Hildebrand (1938: 336) and disagree with those of Meek (1914: 127) and of Behre (1928: 323–24). Wagner may well have taken this species, along with *C. altifrons*, only on the Pacific side of Chiriqui province, though he stated (1865: 90) that he took it in the middle course of the streams of both drainages of Panamá.

ELEOTRIDAE

Eleotris picta Kner and Steindachner, 1863

Eleotris picta? n.—Kner and Steindachner (in Kner, 1863: 223–24; 1865: 18–21, pl. 3, fig. 1—misspelled *pictus* in 1865 text, but not on plate), "Rio Bayano, Südseite von Panama" (1863); "Neu-Granada [properly, Panamá] und aus dem Rio Bayano" (1865).—The original (1863) diagnosis of this species has been overlooked. Its synonymy and distribution have been treated in a separate paper (Hubbs, 1953).

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The Ecological Niche of the Pygmy Swordtail, *Xiphophorus pygmaeus,* in the Río Axtla, Mexico

MYRON GORDON

IN 1932, on an expedition to northeastern México for the purpose of making a survey of the freshwater fishes of the region, John Ross, Joseph Whetzel and I collected a number of species from the Río Axtla, a mile or so upstream from the village of Axtla in the state of San Luis Potosí. This river is in the basin of the Río Pánuco system. The collection was made in April, in the dry season of the year, in a small pool which was about twenty feet long, ten feet wide and three feet deep. This pool was apparently scooped out by the swirling waters of an eddy during the previous rainy season and left isolated by the subsequent subsidence of the water level in the main river bed. At the time the collection was made, the main current of the river raced by about ten feet away from the pool.

The water within the restricted area of the pool was stagnant, devoid of aquatic plants, and murky-white in color; the bottom was muddy. Fish and tadpoles were apparently in great distress, for the surface film of the pool was constantly being broken by them as they rose to the surface to gasp for air. Quite a number apparently had died during the past 24 hours but many were in a perfectly healthy state.

A field inspection of the specimens collected revealed only two groups of fishes: a ubiquitous characin of the genus *Astyanax*, and a number of poeciliids of the genera *Gambusia*, *Pseudoxiphophorus* and *Xiphophorus*. Other representative species of the typical Río Axtla fauna must have died off.

From this pool the first living specimens of *Xiphophorus montezumae* Jordan and Synder were sent to the United States to serve as an aquarium fish and for the purpose of furthering genetic studies on the xiphophorin fishes. From this pool, too, many red-tailed specimens of *Xiphophorus* (*Platypoecilus*) *variatus* were shipped alive to the United States. In addition to those taken alive, a large representative collection was preserved for detailed laboratory analysis. At the Museum of Zoology of the University of Michigan, while sorting the species taken on this expedition, a small, imperfectly developed male *Xiphophorus* was found that represented neither *Xiphophorus montezumae* nor *Xiphophorus variatus*. Its color pattern, particularly the peculiar distribution

of the melanophores, was quite distinctive. Since the gonopodium was imperfect, the taxonomic characters of this structure could not be utilized in determining the identity of the species. No other specimen like it was found elsewhere in the Río Pánuco system, nor were any taken on a previous expedition to México in 1930. The specimen was tentatively regarded as a new species.

Another opportunity to collect fishes in the Río Axtla was made possible in 1939 through the generosity of the John Simon Guggenheim Memorial Foundation. The entire day of March 15 was spent fishing in the Río Axtla with James W. Atz, of the New York Aquarium. Although we collected both *X. montezumae* and *X. variatus*, as well as other kinds of fishes, we did not locate the new xiphophorin. Later that year, upon my return from southern México in company with Salvador Coronado, formerly of the Méxican Government fisheries department, we spent two more days in the Río Axtla and a week more fishing in adjoining watercourses without finding the new form. Because it had been my experience that the platyfishes and swordtails could most easily be found and caught in the shallow waters of the stream, in isolated bodies of water not far from the main stream, or in spring runs in shallow, weed-entangled quiet waters leading to the main stream, we concentrated our efforts in these areas rather than in the swift, deep waters of the undercut slopes.

The pygmy swordtail was found in large numbers quite by accident on April 14, 1939. Towards the end of another fruitless day of fishing in the usual places, we decided to go swimming before returning to our camp. We crossed over to the undercut slope where the water was swift and about eight feet deep. After diving in for a swim, I clambered back to shore where I saw a dense stand of aquatic tape-grass—a plant very much like that of *Vallisneria*—growing along the steep, submerged banks of the stream. The plant's supple, leaf-like branches, about two feet long, waved almost horizontally in the sweep of the strong current. In between the long filaments of the weeds, I got a fleeting glimpse of many tiny, thin, minnow-like fishes which I could not recognize. With Coronado's help, we managed to get some of them in our minnow seine; but most of them were so small that they slipped through the ¼-inch meshes. From the few that we eventually got into a glass collecting jar, I recognized that it was identical with the imperfect male collected in 1932. The species was subsequently described as *Xiphophorus pygmaeus* by Hubbs and Gordon (1943, COPEIA (1): 31–33.).

We fished until about 200 were obtained, most of which were preserved in formalin, but about 50 more were sent alive to the New York

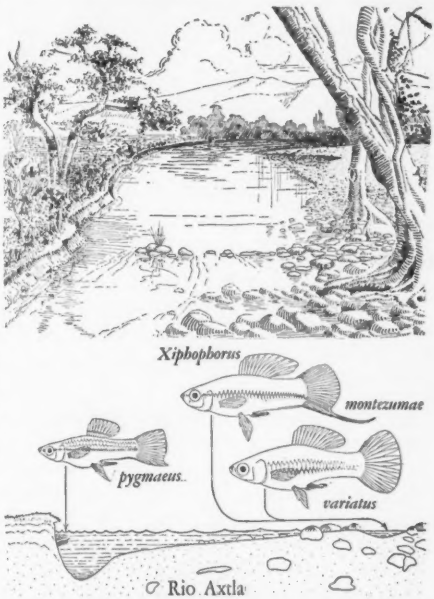

Fig. 1. Habitat of three species of *Xiphophorus* in the Río Axtla, at Axtla, San Luis Potosí, México. (Drawing by Donn E. Rosen.)

Aquarium. It seemed to me remarkable that this particular ecological niche harbored a pure culture of the pygmy swordtail.

The pygmy swordtail is isolated from other species of xiphophorins, despite the fact that it is found in the same cross section of the Río Axtla. It lives along the undercut slopes in deep, fast water, whereas *X. montezumae* and *X. variatus* occur together along the slow, shallow water of the slip-off slope (Fig. 1). Moreover, the range of the pygmy swordtail must be quite restricted, since it has been reported only from the Axtla area, whereas its

related species have been found in more than one hundred stations in the basin of the Río Pánuco and in several of the independent estuaries and smaller streams to the south.

The distributional picture of the three closely related xiphophorin species is as follows: *X. variatus* is usually found alone in the lowland areas. In the middle section, in the Río Axtla which is about midway between lowland and headwater areas of the main Río Pánuco, the pygmy swordtail stays close to the eroding bank in the deep, rapid waters, while a few individuals of the other two species hover near the opposite shore in shallow and sluggish water. In the uplands, *X. montezumae* is found exclusively in the deep pools within the main channel of the river. With the change of the seasons, in times of flood or in periods of drought, they occasionally get mixed up, and it is possible to find the three species living forceably together.

The ecological isolation of these species evidently explains why not a single wild hybrid between any of them has been discovered, although thousands of specimens have been collected and critically studied. This takes on added significance when it is realized that under laboratory conditions, when their choice of mating partners is restricted, they are capable of producing hybrids of every possible combination.

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Radiography of Small Fishes for Meristic Studies

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SEVERAL papers have been published in recent years describing techniques for x-raying fishes and pointing out the application of roentgenography to fishery work. This paper results from experiments with small salmon (*Oncorhynchus*) and eel pouts (Zoarcidae), designed to develop more practical methods for meristic studies.

The suitability of the x-ray technic in ichthyology has been emphasized by Gosline (1948). He pointed out, however, that very small specimens present technical difficulties, so that recourse to staining was suggested. Lamarque (1938) was one of the first to produce microradiographs (radiographs of high resolution). He fabricated equipment capable of providing very soft radiation filtered only through a lithium shield. Clark (1940: 183) pictured a beetle radiographed with grenz rays (very soft x-rays) generated at 4,000 volts. Tirman and Banker (1951) presented methods for obtaining microradiographs of tissue sections 0.3 mm. thick, using fairly hard radiation from a diagnostic x-ray unit. This method, however, is suitable only for thin specimens. Equipment described by Schmidt (1952) for microfossils involved soft radiation, but necessitated fastening the specimens to the film holder in a vertical position because the beam could be directed only horizontally. The published literature suggests, therefore, that solely by the use of soft radiation can microradiographs of relatively thick specimens, such as small fishes, be obtained.

The most accessible source of soft radiation of high intensity is to be found in x-ray diffraction units. Reasons for the superiority for microradiography of the diffraction over the diagnostic type of tube warrant explanation. Since the radiograph is a shadow of the specimen on the film cast by the x-rays emanating from the source at the anode, it is apparent that, for a given separation between specimen and film, a small source will produce a sharper shadow than a large source. The beam of primary radiation from the anode spreads as it emanates so that it covers an area of the tube window much larger than the original source. In penetrating the window the beam generates secondary radiation which tends to blur the picture because it originates from so large an area. The amount of secondary radiation is

X-radiographs on Kodalith film using a Machlett 0–2 diffraction unit with beryllium window

Upper: chinook salmon, *Oncorhynchus tshawytscha* Walbaum, 33.5 mm. in standard length; 10 PKV, 10 MA, 6 inches, 16 minutes; 5.8 diameters.

Lower: tail of a 16-cm. eel pout, *Lycodes brevipes* Bean; 50 PKV, 12 MA, 30 inches, 15 minutes; 13 diameters.

Dorsal and anal rays of the salmon appeared on the film, but, because of the limitations of the printing paper, they do not show.

slight in a diffraction tube with its anode close to the small, thin window which consists of beryllium of low atomic number. By contrast, the secondary radiation of a diagnostic tube is many times greater because of its larger, thicker, more distant window that consists of glass with effective atomic number more than twice as great. Furthermore, the high degree of absorption by the glass window necessitates higher voltages, which in turn increase the secondary radiation. Also to be considered is the secondary radiation arising within the specimen. By scattering, these rays fog the film, tending to make the shadow less distinct, and again the effect is more pronounced with the diagnostic tube.

For our work the use of a water-cooled Machlett 0–2 X-ray Diffraction Unit with a copper target and a beryllium window was obtained. Cost of the unit is approximately $2,000. The tube can be directed downward, which obviates the necessity for attaching the specimens. Available peak kilovoltages range from 1 to 50, but 10 PKV was the lowest used in order to avoid excessive absorption by air and soft tissues at lower energies. Kodalith Ortho Type 2 film produced sufficiently fine grain and was developed for 1 minute in Dektol diluted with 2 parts of water. The chief shortcoming of the film is the long exposure time required. Industrial x-ray film is faster but less suitable because of its coarser grain. The film was placed in light-proof envelopes of black velour paper which were satisfactory except at energies of 10 PKV or less, when the fibers of the paper appeared in the background. Fish preserved in a straight position were blotted and laid on the film envelope with a sheet of thin cellophane to protect the envelope from moisture. A second sheet of cellophane above retarded drying of the specimens. Since most of the eel pouts had been preserved in a curled position, they were straightened and held flat between two sheets of cellulose acetate, 0.2 mm. thick, tacked to the block of wood supporting the film envelope. Specimens held against their tendency to curl sometimes produced blurred pictures by moving during the exposure. Conditions for a typical exposure of a field 6 by 8 inches, using as subjects 2-inch salmon or 4-inch eel pouts, were: 50 PKV and 12 milliamperes (MA) to the tube, and a 5-minute exposure at 24 inches from the anode. For small fishes low voltages were used, but even the softest radiation would not distinguish cartilage from other tissue before ossification had begun. In addition to the current work of one of the authors (W. H. B.) on eel pouts, Mr. A. H. Seymour of the Applied Fisheries Laboratory has used this procedure on several hundred 2-inch chinook salmon for meristic study by exposing 24 fish at a time on 5 by 7 inch films. It need hardly be mentioned that appropriate radiological safety precautions should be observed for the protection of personnel.

After processing, the negative may be held between glass plates for examination with the binocular microscope. It was possible to count fin rays and vertebrae of *Gambusia* as short as 9 mm. in standard length, and of salmon 35 mm. long. The minimum size of eel pouts for resolution of detail was 35 mm. for vertebrae and 70 mm. for fin rays. The positives (Pl. I) show the capabilities of the method with the chinook salmon and an eel pout.

Mr. Tim Sanderson, General Electric X-Ray, Seattle, gave assistance and suggestions at the beginning of the project, guiding it into fruitful channels. Without the cooperation of the following individuals from the University of Washington this study would not have been completed. Dr. Richard C. Snyder of the Department of Zoology and Dr. Charles N. Lester of the Health Center made available diagnostic x-ray machines used in some of the preliminary experiments. Dr. Lyle H. Jensen, Department of Anatomy, School of Medicine, permitted the use of the x-ray diffraction machine and generously gave technical and theoretical advice in its use.

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Distribution, Life History, and Morphological Variations of the Southern Brook Lamprey, *Ichthyomyzon gagei*

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SINCE its original description, the southern brook lamprey, *Ichthyomyzon gagei* Hubbs and Trautman (1937), has received little attention. The original description was based on 10 adults and 2 ammocoetes from Alabama, Louisiana, and Oklahoma. Additional data have been added by the few brief papers mentioned below, which supply some information on geographical distribution, size, and habitat. This paper summarizes the available information regarding extensions of the known range of the species, and presents a description of the habitats of larvae and of spawning areas, observations on spawning habits and fecundity, notes on the growth and development of ammocoetes, and morphological variations within the species.

Acknowledgements.—Reeve M. Bailey, University of Michigan Museum of Zoology (UMMZ), confirmed the identification of the specimens collected in 1948. Robert R. Miller loaned specimens for study. Ernest C. Lachner examined type material in the U. S. National Museum (USNM). Edgar Evans, of Tallahassee, Florida, loaned his material and gave permission to use data in his unpublished master's thesis. Other persons who loaned specimens were William M. McLane, Florida Game and Freshwater Fish Commission; Edward C. Raney, Cornell University (CU); Ralph W. Yerger, Florida State University (FSU); Royal D. Suttkus, Tulane University (TU); and Clark Hubbs, University of Texas (UT).

RANGE

Hubbs and Trautman (1937: [illegible] presented a map on which the southern portion of the range of *Ichthyomyzon gagei* was shown to extend eastward to include the Alabama River System and westward to, but not including, the Sabine River System. Recently published records have extended the known range of this species westward along the Gulf drainage to include the Illinois River in Oklahoma (Bailey, 1947) and the Neches River System in Texas (Bailey, 1947; and Knapp, 1951). Eastward extensions in Alabama include the Chattahoochee River System and the Conecuh River System (Raney, 1952).

Unpublished data from other collections to the east and west of the original limits of the known range have been made available for this paper. The eastward extensions of the range of *I. gagei* are into tributaries of Choctawhatchee Bay, Florida; the Chattahoochee River System, Georgia; and the Ochlockonnee River System, Florida. Westward, the range is extended into the Trinity River System and the San Jacinto River System in Texas. The distribution of collections used in this study is given below according to river systems.

MATERIAL EXAMINED

A total of 100 adult southern brook lampreys were examined in this study (58 males, 40 females and 2 sex undetermined). These are in the University of Georgia (UG) and Alabama Polytechnic Institute (API) and in the institutions mentioned above. The distribution and disposition of these specimens are given below by river systems.

Ochlockonee River System

FSU No. 117 (2 females)—Florida, Leon Co.: tributary to south side of Lake Talquin, 20.1 mi. w of Tallahassee on Rt. 20; W. Hart and D. Chalfin; Feb. 18, 1951.

Chattahoochee River System

UG Nos. 192 and 192a (9 males and 3 females)—Georgia, Cobb Co.: Nickajack Creek, at Camp Highland; D. C. Scott; March 4 and 11, 1951.

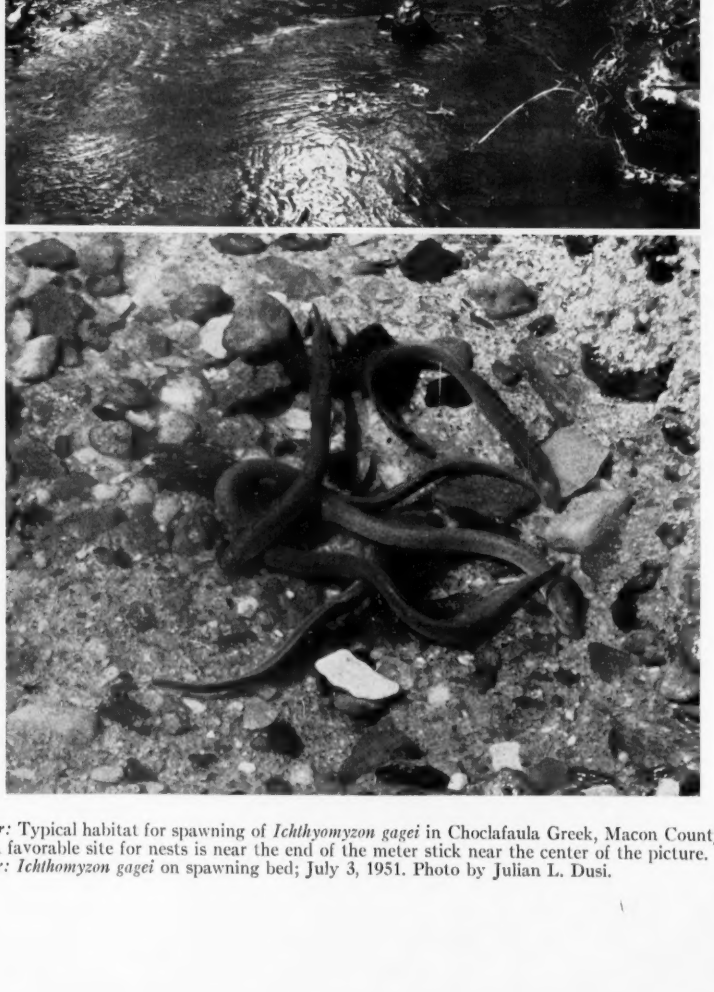
CU No. 13982 (8 males and 5 females)—Alabama, Russell Co.: Uchee Creek, 3.1 mi. E of Marvyn, Highway 80; E. C. Raney; March 24, 1948.

CU No. 17660 (1 male and 1 female)—Alabama, Houston Co.; Omussee Creek, 5.8 mi NE of Dothan; E. C. Raney; March 28, 1950.

CU No. 18231 (1 female)—Alabama, Henry Co.: 2.2 miles w of Fort Gaines, Ga.; E. C. Raney; March 28, 1950.

Tributaries of Choctawhatchee Bay, Florida

TU No. 319 (1 female)—Florida, Walton Co.: tributary of Lafayette Creek (4-mile Creek), 0.7 mi. w of Freeport, Highway 20; Royal D. Suttkus; Feb. 4, 1951.



Upper: Typical habitat for spawning of *Ichthyomyzon gagei* in Choclafaula Greek, Macon County, Alabama. A favorable site for nests is near the end of the meter stick near the center of the picture.
Lower: Ichthomyzon gagei on spawning bed; July 3, 1951. Photo by Julian L. Dusi.

Alabama River System

API No. 743 (13 males, 10 females)—Alabama, Macon Co.: Choclafaula Creek near Lee Co. line; tributary of Tallapoosa River; J. S. Dendy; May 1, 1948.

API No. 761 (18 males, 8 females)—Alabama, Macon Co.: Choclafaula Creek near Lee Co. line; tributary of Tallapoosa River; J. S. Dendy and J. L. Dusi; May 3, 1951.

API No. 744 (1 female)—Alabama, Lee County: M. A. Barnes; May 20, 1932.

API No. 760 (1 sex undetermined, 2 females metamorphosed in aquarium)—Alabama, Macon Co.; tributary to Choclafaula Creek near Lee County line; J. S. Dendy; April 22, 1950.

Tangipaha River System

UMMZ No. 64494 (2 males, 1 female; paratypes)—Louisiana: tributary to Tangipaha River near Kentwood. Mrs. L. L. Travis (received from Percy Viosca, Jr., of the Southern Biological Supply Co., through Professor Simon H. Gage) collected before May 1, presumably late in April, 1930.

Red River System

UMMZ No. 107043 (4 males, 2 females, paratypes)—Louisiana: stream ¼ mi. S of Dry Prong, Grand Parish; presumably a second tributary of Little River; Donald J. Ameel, Leslie R. Hedrick, and E. P. Creaser; May 29, 1932.

Arkansas River System

UMMZ No. 119976 (1 female)—Oklahoma: Barren Fork Creek, Tahlequah; Jack Baker, presented by G. A. Moore, 1931.

Neches River System

UMMZ No. 143081 (1 adult)—Texas, Nacogdoches Co.: Addison Lee; March, 1936.

Trinity River System

UT No. 1435 (1 female)—Texas, Polk Co.: tributary of Long King Creek, 2 mi. N of Goodrich on U. S. Highway 59; Clark Hubbs; March 23, 1951.

UT No. 1593 (1 male and 1 female)—Texas, Polk Co.: 3 mi. E of Livingston; Clark Hubbs; March 23, 1951.

San Jacinto River System

UT No. 1184 (1 male)—Texas, Montgomery Co.: Covey Creek; 8 mi. E of Conroe; Clark Hubbs; March 23, 1951.

UT No. 1504 (1 male)—Texas, Montgomery Co.: Peach Creek, 14 mi. E of Conroe; Clark Hubbs; March 23, 1951.

Habitat

Observations were made by the authors on lamprey habitats in Choclafaula Creek, a tributary of the Tallapoosa River in the Alabama River System, and in Nickajack Creek, a tributary of the Chattahoochee River in Georgia.

Choclafaula Creek drains an area of Chesterfield sandy loam in Lee County, Alabama, between the towns of Auburn and Loachapoka. It runs through Gilead sandy loam and Iuka silt loam near the Lee–Macon County line in the area where spawning lampreys were found. Approximately 3 miles farther downstream, the dam at Vaughan Mill blocks upstream migration of fishes except during extreme floods.

Where lampreys were collected, the stream varied in width approximately from 6 to 30 feet. In the narrow areas, the depth rarely exceeded 1 foot; no pools were found over 3 feet deep; and most of the bottom material was sand or gravel. No bedrock or rubble was present in the immediate area.

Adult lampreys, engaged in spawning activities, were found on the upper edges of riffle areas where the bottom was of gravel and sand (Pl. I, Upper). Ammocoetes were most abundant in accumulations of leaves and other organic debris on the bottom in slack, marginal water, usually at the downstream ends of sand bars or below obstructions in the stream. These masses of debris were frequently overlaid with mud or sand, and they released quantities of methane when disturbed. Several springs near the creek caused the water to be cooler below the springs than above (69°F. and 79°F., respectively, on June 10, 1951). Most of the stream ran through woodland and was well shaded by marginal vegetation.

Ammocoetes, identified by Reeve M. Bailey as being presumably those of *Ichthyomyzon gagei*, were collected in Crossways Creek (Conecuch River System), Escambia County, Alabama, on May 1, 1949. The collection was made immediately downstream from the bridge on U. S. Highway 29. In that area the stream was approximately 4 to 8 feet wide and not over 2 feet deep in the pools. The water was low in turbidity but was dark brown because it drained a swampy region.

The section of Nickajack Creek in which lampreys were collected is in Cobb County, Georgia, about 6 miles northwest of Atlanta on the property of Camp Highland of the Atlanta Y.W.C.A. The creek at this point is typical of many streams of the Piedmont Region of Georgia. There are long stretches of gliding sandy-bottomed streams averaging 35 feet wide and less than 2 feet deep. These alternate with shorter, stony and bedrock riffles where the width of the stream some-

times is reduced to 6 feet. A small gravel-bottomed tributary 3 feet wide and less than a foot deep enters the creek at this point. This tributary passes through a culvert about 50 yards from the creek and drops 3 feet into a pool 4 feet deep. Thus, only the short, lower portion of the tributary is accessible to fish from Nickajack Creek.

A few adult lampreys were taken in Nickajack Creek where it tumbled over boulders and bedrock, but most of the 12 specimens collected were obtained from the tributary and the pool below the culvert. A reliable observer reported seeing what must have been a spawning aggregation of lampreys in the shallow gravelly portion of this tributary about 20 yards from its entrance into Nickajack Creek; this was late in March, 1950. Spawning activities had not begun when our collections were made on March 4 and 11, 1951, and subsequent visits to this area were rendered fruitless by spring rains. Thus, spawning was not witnessed by the authors at this locality.

An intensive search of the few mud banks in Nickajack Creek in this area failed to yield any ammocoetes.

The Nickajack Creek locality differs from the Choclafaula Creek locality in having a much steeper gradient, in having large areas of rubble and bedrock bottom, and in having much less suitable habitat for ammocoetes.

Spawning Habits

Stream observations.—Spawning of *Ichthyomyzon gagei* was observed in Choclafaula Creek on May 1, 1948, near the point where the stream crosses the Lee and Macon County line. Three or four nests were found on the upstream end of a riffle where the bottom material was gravel and sand, and the water was from 2 to 3 inches deep. The largest pebbles were about 2 inches in diameter. These nests consisted of roundish depressions 6 to 8 inches wide and approximately 2 inches deep.

The number of lampreys participating in nest-building and spawning activities ranged from 5 to 20 or more per nest. They attached themselves to pebbles with their sucking-discs and swam rapidly in an upstream or lateral direction removing the pebbles from the nest. On one occasion two individuals attached themselves to one stone which was too large for a single lamprey to move and thus succeeded in removing it. This behavior may have been accidental cooperation. Some lampreys moved about from one nest to another, thus, giving the nesting an appearance of a community project. This behavior is in contrast to the strong tendency toward monogamy noted in *Petromyzon marinus* Linnaeus, as recorded by Applegate (1950). When a hand was placed in the nest, those lampreys that were touched and a few others in the immediate vicinity moved away rapidly, but the rest remained undisturbed. Individuals that moved away returned shortly or joined another group at a nearby nest. This was in contrast to the shyness of individuals apparently preparing to spawn in Texas on March 17, 1950, as reported by Knapp (1951). Schultz (1930) observed that *Lampetra planeri* Bloch was not easily frightened when spawning.

The activities observed included both nest building and spawning. Periodically efforts to move pebbles ceased, and were followed by violent swimming movements that caused disturbance of the sand, which was carried downstream a foot or two by the combined actions of the lampreys and the current of the stream. When observers were not too near, minnows darted into the disturbed sand, evidently feeding on eggs that were mixed with it. Precise observations on the spawning act could not be made because of the reflection from the surface of the water, the large number of individuals in the nest, and the disturbance of the sand.

Most of the individuals from the largest nest were collected. Some escaped and were observed to swim under a board at the edge of the water. The board, approximately 3 feet long and 6 inches wide, was turned over and its under side was found to be almost covered with lampreys. A conservative estimate of the number present was placed at 75. Among the individuals collected from the nest, males outnumbered females by about 4 to 3. Possibly those under the board were largely females in waiting.

Some of the individuals were brought back to the laboratory alive, and kept overnight in creek water. The following day most of these were dead.

On May 3, 1951, spawning was observed

again. No rain had fallen for several days, and the weather had been warm. On intervening years since 1948, high water had made observations impossible. Two lamprey nests were located in Choclafaula Creek a few hundred yards downstream from the locality where spawning had been observed in 1948. They were about a yard apart on the upstream margin of a shallow gravelly riffle. One nest contained 2 lampreys and approximately 12 were observed in the other. The area was between the entrance of two springs, and the temperature of the water was 75°F. The water was warmer upstream from the upper spring, and was somewhat colder below the lower spring. No nests were seen below this immediate area, but abandoned nests and nests with only one or two lampreys on them were found above the mouth of the upper spring. Time of spawning in different parts of this creek may be somewhat dependent upon the location with respect to the cold water coming from the springs.

The first two nests found were quite near the margin of the stream. The one occupied by only 2 lampreys was located among the submerged roots of a stump at a depth of approximately 3 inches. The nest with approximately 12 lampreys was larger, at the waters edge, and in water only about one inch deep. No nest-building activities were observed in either nest; only periodic violent shivering movement with intervals of gentle writhings between. Occasionally one or two individuals moved over to the nest containing only two individuals. Although a tripod camera was set up almost directly over the larger nest, it did not seem to disturb the occupants. Shifting clouds necessitated considerable waiting for suitable light. During this time about half of the lampreys swam leisurely away. Therefore, the photograph (Pl. I, Lower) shows only six individuals on the nest.

During one of the periods of violent movements of the whole group one individual, presumably a female (judging from actions observed in an aquarium), swam so vigorously that it went entirely out of water onto shore. It returned immediately.

Additional nests were seen on the upstream margins of shallow riffles over a mixture of sand and gravel. Most of these nests were abandoned. The presence of eggs in the sand in and near the abandoned nests showed that spawning had occurred. However, these eggs were not reared to make certain that they were lamprey eggs. Upon reaching the spot where spawning had been observed in 1948, it was seen that the bottom materials had shifted to such an extent that the site was no longer suitable for lamprey nests. No nests were observed downstream from a flat stone as described for *Ichthyomyzon greeleyi* Hubbs and Trautman by Raney (1939). Only one nest was near a sizeable object, namely a stump.

On May 3, 1951, it appeared that the spawning of *Ichthyomyzon gagei* was practically over. Judging from the range in sizes of the young-of-the-year ammocoetes (8 mm. to 32 mm.) collected June 10 through 15 (Fig. 1), spawning

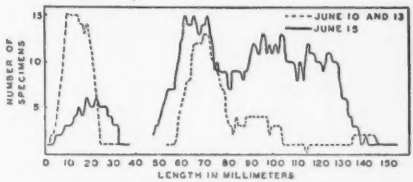


Fig. 1. Length-frequency curves for ammocoetes of *Ichthyomyzon gagei* collected on June 10 and 13 and on June 15, 1951. Data have been smoothed by a moving average of 15 millimeters.

must have extended over several weeks. This may be normal for the species or it may reflect the influence of the springs on the temperature of the water at various points in the stream. Examination of specimens from Raney's (1952) collection (CU No. 13982) showed that spawning had begun on March 24, 1948, in a tributary of Uchee Creek, Russell County, Alabama, when the temperature of the water was 59°F. Of the five females in his collection, all but one had shed half or more of their eggs.

Aquarium observations.—The 26 adults and one ammocoete collected on May 3, 1951, were brought to the laboratory and placed in an aerated aquarium without sand. Most of the individuals crowded into corners and attached themselves to the sides or bottom of the aquarium. Unless disturbed the lampreys remained rather inactive, although an occasional individual might swim around for a while. Individuals that attached themselves to the glass sides of the aquarium displayed the

tooth pattern of the sucking disc to good advantage. Swimming lampreys usually moved toward the darker areas in the aquarium, but when they were attached to the glass, strong light did not disturb them enough to make them move. They rarely moved when touched by another lamprey, but usually swam away when touched by a glass rod or the observer's hand. Occasionally, however, by pushing gently on the anterior end and not touching the rest of the body, it was possible to slide an attached individual from place to place without disturbing its composure.

About 10 PM, May 7, approximately 2 gallons of sand were placed in one end of the aquarium. (The depth of the water was 5 inches, surface dimensions 24 × 9 inches, and the temperature was 70°F.). Immediately great excitement swept the entire group. All the lampreys left their respective corners and crowded to the place where the sand was present. They attached themselves to the glass side of the aquarium and began to vibrate their bodies rapidly. In a few minutes they had swept out a bed 2 to 3 inches deep and 6 to 8 inches wide. The aquarium conditions and the fact that spawning had been interrupted for a period of 4 days may have resulted in abnormal haste in the spawning act. Males did not attach themselves to the backs of females and glide forward to the location above the branchial basket as described by Schultz (1930) for *Lampetra planeri*. The females attached themselves to the glass and the males attached themselves to the sides of the females, then quickly curled their tails around the females in such a position as to bring their vents near each other. The clasping was followed by rapid vibrations of the body and lasted only a few seconds. The vibrations continued for several minutes with many lampreys side by side and close together. On at least one occasion, a female had a male attached on either side and was in two embraces at once. One male was seen to embrace two other lampreys simultaneously. The force of the quivering appeared to be so great as to almost overcome the suction of the sucking-disc and caused a conspicuous arch to occur in the branchial region. One male attached himself to the glass, embraced another lamprey in the region just posterior to the gills, and wriggled with such vigor that the second individual was detached from the glass and was held shaking in the embrace.

After the first wave of excitement, a few individuals moved to the opposite end of the aquarium and did not participate in the mating even when disturbed from their resting places. An ammocoete that had been included in the collection swam about excitedly rather than burrowing into the sand as they usually did when placed in an aquarium with sand. Sometimes it joined the spawners, and sometimes it stayed with the others.

Periods of great activity came in waves at irregular intervals. Usually a female initiated the activity and was followed by numerous males; then the whole group became excited. One female swam vigorously upward until her sucking-disc was attached to the side of the aquarium 2 inches above water level. There she thrashed the water for a few moments. No male followed and she returned. Another female quiveringly swam away from the group and was not followed by a male. She returned by backing rather than by turning around. Occasionally an individual appeared to push some of the sand back into the nest rather than continue to drive it in the direction that the group was sending it.

After a time of great excitement and activity, individuals came up near the surface for rest. They left the group and attached themselves to the side of the aquarium. Respiratory movements of individuals, which had just started their rest, were rapid and irregular. The branchial movements appeared to be in double pulsations with very brief pauses rather than regular movements, as in more quiescent animals. After hanging on the glass for about 10 minutes they usually returned to the group. The respiratory movements were too rapid to count when lampreys first came to rest. After 10 or 15 minutes of resting, 100 respiratory movements requiring only 37 to 40 seconds were recorded.

After a half hour or so of spawning, the areas of the vents in both males and females appeared reddened as if bruised or hemorrhaging. This was not surprising when the vigor with which that part of the body had been rubbed in the sand was considered. After about an hour of spawning the females, which

came up to rest on the sides of the aquarium had teeth missing and the edges of the discs bleeding. Only one individual, a female whose mouth was clogged with fungus, died prior to May 7. Evidently she had lost teeth and damaged the oral disc while spawning in the creek in the same manner as those that spawned in the aquarium.

In all the spawning activity, very few eggs could be seen. It seems probable that the eggs were shed a few at a time. The following day a few eggs, which by this time had reached the four-cell stage, were found in the sand. None of these eggs was observed to hatch, even though the water was well aerated. Evans (1949) successfully hatched eggs of this species in small containers of creek water.

Observations were continued for four hours. The lampreys seemed to show no loss in vigor, and appeared in excellent condition, except for the bruised lips, vents, and dorsal fins, and the missing teeth.

The following day, May 8, all individuals except four were removed. These four were left to determine how long the lampreys would live in an aquarium after spawning. The first one died May 9 and the last June 3, or 26 days after spawning in the aquarium. No attempt was made to feed them, because, as in adults of other species of non-parasitic lampreys, the digestive tracts in spawning adults of *Ichthyomyzon gagei* are reduced to tiny thread-like dimensions.

Because of the difficulty in making measurements and tooth counts on twisted and contracted lampreys, the specimens for preservation were anesthetized with ether and placed with their oral discs against an enamel pan. The discs held the animals in place while 10 percent formalin was added. The discs adhered to the pan until the animals were fixed in a position that exposed the teeth and lingual laminae most satisfactorally.

Fecundity.—As stated by Vladykov (1951), "the published data on the fecundity of lampreys are very scanty." He listed the average number of eggs per individual for each of several species as follows: *Ichthyomyzon fossor*, 1,524; *Lampetra lamottei* (*Entosphenus lamottenii*), 2,339; *Ichthyomyzon unicuspis*, 19,012; *Petromyzon marinus* (landlocked from Lake Michigan, Wisconsin), 62,870; *Petromyzon marinus* (landlocked from North Channel, Ontario), 55,913; and *Petromyzon marinus* (anadromous from the St. Lawrence River, Quebec), 171,589. The average of 61,500 eggs per female *Petromyzon marinus* from Michigan, found by Applegate (1950), agrees remarkably well with Vladykov's data.

The number of eggs per female in *Ichthyomyzon gagei* were determined by actual counts (Table I). The specimens from Georgia (UG Nos. 192–192a) averaged 150 mm. total length as compared with the over-all average of 118.7 mm., and contained and average of 2,786 eggs as compared with the over-all average of 1787.4. Two females that metamorphosed in an aquarium were not included in this table. They measured 94 and 116 mm. and contained 705 and 1072 eggs, respectively. Their eggs were free in the coelom and they had swept out a nest as if to spawn; hence partial spawning

TABLE I

EGG COUNTS OF PRE-SPAWNING FEMALES OF *Ichthyomyzon gagei*

Collection date	Museum No.	Total length, in mm.	Eggs attached to ovary	Eggs free in coelom	Eggs attached after spawning
Feb. 4, 1951....	TU 319	101.0	1,000	...	..
Feb. 18, 1951...	FSU 117	118.5	1,264	...	..
Feb. 18, 1951...	FSU 117	110.0	1,187	...	..
Mar. 4–11, 1951	UG 192–192a	150.0	2,308	...	..
Mar. 4–11, 1951	UG 192–192a	147.0	2,785	...	..
Mar. 4–11, 1951	UG 192–192a	152.5	3,264	...	..
Mar. 23, 1951...	UT 1435	111.0	1,221	...	..
Mar. 23, 1951...	UT 1593	127.0	1,620	...	..
Nov. 24, 1951...	CU 13982	112.0	...	878	..
Nov. 24, 1951...	CU 13982	114.0	1,582	...	..
Nov. 24, 1951...	CU 13982	109.0	...	296	..
Nov. 24, 1951...	CU 13982	116.5	...	328	..
Nov. 24, 1951...	CU 13982	106.0	...	109	..
Mar. 28, 1951...	CU 17660	111.0	...	1,806	..
Mar. 28, 1951...	CU 18231	118.0*	1,643	...	..
Apr. 20, 1932...	API 744	112.5	...	66	..
May 1, 1948....	API 743	122.0	...	988	..
May 1, 1948....	API 743	105.0	...	576	..
May 1, 1948....	API 743	114.0	...	1,295	..
May 3, 1951....	API 761	126.5	...	...	1
May 3, 1951....	API 761	118.0	...	...	2
May 3, 1951....	API 761	128.5	...	...	0
May 3, 1951....	API 761	123.5	...	...	2
May 3, 1951....	API 761	119.0	...	...	1
May 3, 1951....	API 761	106.0	...	...	1
May 3, 1951....	API 761	114.0	...	...	5
Average.....	....	118.7	1,787	...	..

* Original measurement 122.5, by Raney.

may have occurred. The females collected May 1, 1948, were on the spawning bed and probably had deposited some of their eggs. Egg counts were made on the three females that appeared to contain the largest numbers of eggs.

Applegate (1950, appendix F, Table 3) showed that in *Petromyzon marinus* the percentage of unspawned eggs ranged from 0.0 to 37.2. The percentage of unspawned eggs in *Ichthyomyzon gagei* could not be determined, but eggs that remained attached to the ovary after spawning were counted. One specimen collected April 20, 1932 contained no free eggs in the coelom but had 66 attached to the ovary. Seven females collected on nests, May 3, 1951, were allowed to complete their spawning in an aquarium, after which none was found to have eggs free in the coelom. The numbers of eggs attached to the ovaries of these specimens were 0, 1, 1, 1, 2, 2, and 5.

TABLE II

MEASUREMENTS OF EGGS IN BODY CAVITIES OF *Ichthyomyzon gagei* COLLECTED IN CHOCLAFAULA CREEK, MAY 1, 1948

Number of eggs measured	Width, in mm.		Length, in mm.		W/L
	Range	Av.	Range	Av.	
10	0.83–0.94	0.90	0.83–0.97	0.95	0.95
9	0.72–0.76	0.75	0.83–0.86	0.84	0.90
16	0.76–1.01	0.84	0.88–1.12	0.96	0.87

The size and shape of mature eggs were studied from specimens that had been fixed in 10 percent formalin and preserved in 70 percent ethyl alcohol for 4 years. The eggs were covered by a transparent shell and were not quite spherical, but none appeared pear-shaped as recorded for *Petromyzon marinus* by Applegate (1950). At one end of the egg, which appeared to be the animal pole, the yolk was flattened and not in close contact with the shell. The average size and shape of the eggs in each of the lampreys is shown in Table II. The shapes of eggs in lampreys collected prior to spawning were distorted because of the pressure of eggs against each other in the ovaries. The shells were not well developed and no spaces were evident between yolks and shells. The average width and length of a sample of these eggs were 0.80 mm. and 0.97 mm. respectively.

AMMOCOETES

Eggs were collected from the Choclafaula Creek spawning area on May 1, 1948, and were allowed to develop under laboratory conditions. Observations on early stages of ammocoetes of *Ichthyomyzon gagei* were recorded by Evans (1949). Some quotations from his unpublished thesis are given here.

> On May 11 eggs and post-hatching stages were obtained by sifting the sand and gravel from the bottom of the spawning depressions with Number 40 screens. The same collecting methods yielded more advanced larvae on May 18 and again on May 25. A fourth collection was attempted on June 1 with no success.

Apparently by this time the larvae had left the nest for their brief free-swimming period as described for *Ichthyomyzon fossor* Reigard and Cummins by Leach (1940). Evans kept larvae alive in fingerbowls filled with their native creek water and studied their development for a period of 16 days. Newly hatched larvae collected by Evans on May 11, 1948, were approximately 5 mm. long and nearly transparent with a greenish iridescence.

> A pronounced downward flexure was seen in the cephalic and caudal regions. Periods of quiescence alternated with shorter periods of seemingly non-directional, violent, threshing, and twisting motion. In the periods of quiescence, the larvae invariably rested on their sides. Specimens anesthetized with chloral hydrate showed no movement of the velum, no signs of the gill slits, and no respiratory activity. The heartbeat was easily observable and was at the rate of about one hundred beats per minute at room temperature of seventy-five to eighty degrees Fahrenheit. Movement of the blood in the blood vessels was clearly discernible. No pigmentation was present and the myomeres were only faintly visible. The eyes appeared as two small spherical, dark bodies well embedded in the anterior cephalic region, situated laterally and posteriorly to the well-defined nasal pit. The mouth showed as a narrow transverse slit. The oral hood had not assumed its typical form. The gut was greatly distended with yolk material.

On May 12 the body was much straighter, particularly in the cephalic region, and by May 16

> the animal had assumed the typical body shape of an ammocoete and the length had increased about 6.5 millimeters. Conspicuous respiratory activity was evidenced by movements of the velum too rapid to be counted. The gill slits were con-

spicuous and the yolk in the gut was greatly reduced. The animals were much more active. On May 17 the ammocoetes were quite active and respiratory movements were extremely rapid. The yolk supply was still further reduced and the posterior end had assumed a greenish color. The ammocoetes collected on May 18 were indistinguishable from living specimens collected May 11. At room temperature the heartbeat of two specimens was seventy and sixty-one times per thirty seconds. The rate of beat of the velum was one hundred times per thirty seconds.

No observable changes in structure occurred between May 18 and 25, although a slight increase in length and a further reduction of the yolk material was noted. At this time a network of small, irregular, blackish pigment cells was appearing over the entire surface of all live specimens including those just collected. There were no observable differences in appearance of the surviving members of all collections. On May 26 all larvae collected the previous day were dead. Some specimens collected May 11 and May 18 were still alive. Evidently acclimatization was an important factor in survival.

From a study of sectioned material Evans found that the gill-clefts of the smallest specimens were unformed. Transparent areas indicated the presence of the well-developed gill pouches. The continuous fin began dorsally over the pharynx, extended posteriorly around the caudal region, and ended just posterior to the anus. In the younger larvae the oral hood was separated from the buccal cavity by the still undivided velum, and no oral papillae were present. Older stages showed the velum to be well formed and to consist of two flaps on either side of the oral aperture proper. The dorsal lip and two side flaps of the hood were lined with numerous, more or less branched, oral papillae. Those in the peripheral region were smaller and less branched than those on the more central portions.

Collecting methods.—Collections for study of the distribution of sizes of ammocoetes were made in Choclafaula Creek on July 10, 13, and 15, 1951, within one fourth mile of the spawning area. Electrical methods were tried. A Model-T Ford spark coil, connected to dry cell batteries, did not bring up ammocoetes. A telephone generator, such as has been used illegally for obtaining catfish, was tried, and a few ammocoetes were brought up when the generator was turned vigorously and the terminals were only a foot or so apart. However, the lampreys recovered quickly and were difficult to capture. A more powerful apparatus, such as has been used by Churchill (1947) and others, was not available. Electricity was, therefore, abandoned and manual methods were employed.

A seine made of plastic window screen similar to the one used by Moore (1950) and operated by two persons was quite successful. The bottom of the seine was pushed down into the bottom of the stream near a mass of debris and was held down with one hand while the other hand was used to pile bottom material quickly onto the seine. The ends and edges of the seine were raised promptly to prevent escape of the catch. The mud was usually washed out by rocking the seine backward and forward in the stream. The seine and its contents were laid out on a sandbar for close examination. Some of the smallest ammocoetes were able to make their way through the meshes of the screen.

Organic debris overlaid with an inch or so of sand produced young-of-the-year lampreys and intermediate sizes. None in the largest size-group was found where much silt or sand overburden covered the debris. Concentrations of debris, chiefly leaves, with little or no cover of sand and mud, was the habitat of the largest ammocoetes, as well as of all other sizes, although smaller individuals appeared to be relatively less abundant in this habitat. Collections were made above and below the outlets of the springs and one ammocoete was found in the debris at the margin of a spring.

Growth.—The longevity of lampreys is of considerable interest. Schultz (1930) presented a statistical analysis of the rate of growth of *Lampetra planeri* based on measurements of 2,915 individuals. He concluded that earlier workers placed too much confidence in minor modes on size-frequency curves as indications of year classes. Applegate (1950) collected 1,384 ammocoetes of *Petromyzon marinus* and, prefaced by some skepticism, proposed that only 3 age-groups of ammocoetes are typically represented in the spring months (spawning occurs in the summer).

The ammocoetes used in a size-frequency study were collected in Choclafaula Creek on June 10, 13, and 15, 1951. They were brought to the laboratory, anesthetized, and preserved in 10 percent formalin. To avoid errors due to shrinkage, measurements were made within 24 hours after fixation. However, because

Ichthyomyzon castaneus and *Lampetra aepyptra* are also present in the Alabama River System, 112 ammocoetes were sent to Dr. V. D. Vladykov for species identification. Of these 5 were determined as larvae of *Lampetra aepyptera*, and the rest as *Ichthyomyzon gagei*. The 39 specimens of *Ichthyomyzon gagei* collected on June 10 and 13 and the 68 collected on June 15 were re-measured by Dr. Vladykov in March or April 1952. Of necessity the second measurements have been used in constructing size-frequency curves. The curves (Fig. 1) were smoothed by using a moving average of 15 mm. The replicated discontinuity of the curves between the smallest size-group and the next larger size-group indicates clearly that the young-of-the-year ammocoetes could be distinguished from older ones by size alone. The general forms of the curves for larger size-groups agree rather closely and indicate 3 size-groups in the population. If *Ichthyomyzon gagei* undergoes 1 year of rest as an ammocoete, prior to metamorphosis, as Leach (1940) indicated for *Ichthyomyzon fossor*, upper size groups would contain a mixture of ages. From the data at hand, it is impossible to determine with certainty the age of *Ichthyomyzon gagei* at spawning.

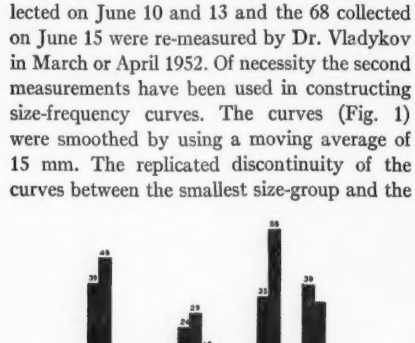


Fig. 2. Counts on available specimens of *Ichthyomyzon gagei*.

Morphological Features

The examination, of approximately ten times as many individuals as were available for the original description of *Ichthyomyzon gagei* by Hubbs and Trautman (1937), has revealed wider ranges of variations within the species than hitherto recorded. To facilitate comparison with the original description the authors' morphological data are presented in the form of histograms (Figs. 2 and 3) similar to those on pages 28, 30, 35, and 36 in Hubbs and Trautman (1937), except that data for measurements (Fig. 3) have been separated according to sexes. Some specimens were damaged or poorly preserved and could be used for only part of the counts or measurements. The transverse lingual lamina was not included in this study because of the condition of many of the specimens. Points of special interest regarding variation of morphological features are discussed below.

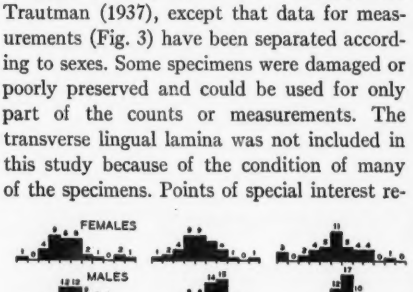


Fig. 3. Measurements (expressed in thousandths of total length) on available specimens of *Ichthyomyzon gagei*.

Number of Myomeres.—The range in the number of myomeres in both sexes was extended considerably beyond that of the type specimens. In a few individuals the number was not the same on both sides.

Supraoral Cusps.—It was found that some of the main teeth in the supraoral row were bicuspid. One male was encountered that had two bicuspid supraorals plus a small median cusp giving a total of 5.

Infraoral Cusps.—The mode of nine cusps which we obtained agreed with the original account; however, the original range of 7 to 10 cusps was extended to 5 to 11 cusps.

Teeth in Circumoral Row.—The chief variation from the original data on teeth in the circumoral row was a greater number. The

females tended to have slightly higher counts than the males.

Teeth in Lateral Rows.—The authors' counts averaged a little less than those in the original description with no conspicuous difference between the sexes. The condition of the specimens was an important factor in determining the number of teeth in the lateral rows, especially in ease of finding the teeth near the distal ends of the rows. If the females had participated in spawning, there were frequently areas of the disc where no indication of teeth remained. Specimens killed with the discs expanded were of much help in this study, and it was essential to collect females prior to spawning in order to obtain an accurate count.

Bicuspid Circumorals.—The original description showed a range of 2 to 8 bicuspid circumoral teeth. The specimens examined in this study had a range of 0 to 10, with a tendency for males to have more bicuspid teeth than females. Tricuspid circumorals were present in 4 females; 2 had 1 each, and 2 had 2 each.

Form and Strength of Disc Teeth.—The teeth of the males appeared to be somewhat longer and stronger than those of the females. All teeth of *Ichthyomyzon gagei* are relatively short and weak as compared with those of its nearest relative, *Ichthyomyzon castaneus*.

Total Length.—The females definitely tended to be longer than the males. The longest individual so far reported appears to be the female recorded by Knapp (1951) with a total length of 166 mm. Other morphological features of that specimen fall within the ranges shown in this paper. Raney (1952) suggested the possibility that individuals in the eastern populations may be shorter than the western ones. The material available for the present study offers no support for this idea. Environmental factors are probably more important than geographical location in determining the size to which the species grows.

Length of Tail.—The authors' data show a reduction but no increase in the relative length of the tail as compared with the original description. The tails of males were proportionately longer than those of females. Several females showed a sexual dimorphism in the form of an upturned tail similar to, though less pronounced than, that of *Lampetra lamottei* as pictured by Vladykov (1949).

Depth of Body.—Some increase was noted in the relative depth of body in the series we examined as compared with the original description. Males were proportionately deeper than females. This was rather conspicuous and was thought to be related to the fact that females had reduced depth because of spawning activities. However, the collection from Nickajack Creek, Georgia, contained no females that had spawned, yet the average depth in thousandths of total length was 85.1 for males and 77 for females.

Length of Eye.—In general the authors' data agree with the original account. The relative size of the eye showed considerable variation, and its diameter was frequently not alike on both sides. In one specimen the eye was missing on one side and the other eye measured 17.6 thousandths of total length.

Length of Snout.—A few individuals had snouts proportionately shorter than those in the original study. The condition of the specimens at time of measurement is important in determining this measurement. In all collections that contained 10 or more individuals, the snouts of males averaged longer than those of females.

Length of Disc.—The measurements for the lengths of discs were highly variable depending upon the manner of preservation. However, in general the males possessed slightly larger discs than those of females.

Summary

The known range of *Ichthyomyzon gagei* is now extended to the East to include the Chattahoochee River System in Georgia and the Ochlockonee River System in Florida. The westerly distribution includes the Trinity and San Jacinto River Systems in Texas.

In a stream, spawning occurred on the upstream margins of riffles where bottom material was composed of sand and gravel. In an aquarium, spawning began immediately when sand was added.

Egg-counts made prior to spawning for 10 females ranged from 1,000 to 3,264 with an average of 1,787.

Length-frequency curves for ammocoetes are

presented, but only the first mode can be ascribed definitely to a year-class.

Morphological characters vary within wider ranges than hitherto recorded.

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Copulatory Adjustment in Snakes and its Evolutionary Implications

Richard A. Edgren

In 1941 Clifford H. Pope published his brief but important paper on copulatory adjustment in snakes. This paper described for the first time the intimate relations between the hemipenis of the male and the vaginal cloaca of the female snake during copulation. His studies were based upon two specimens of *Liophis poecilogyrus* Wied which were killed in coitus and preserved without dislodging the penis. Pope found that the ends of the bifurcated sulcus spermaticus were applied directly to the openings of the oviducts of the female, apparently allowing direct conduction of the sperm to the oviducts. He also described the position of the penial spines and suggested that they function in anchoring the base of the penis in such a way that the distal portion remains in position despite movement of the animals.

The present report deals with a similar situation. Among specimens of the hog-nosed snake (*Heterodon platyrhinos* Latreille) in the collection of the United States National Museum are two individuals which were killed and preserved in coitus. Through the kindness of the authorities of the National Museum I was permitted to dissect these specimens. They were collected by Enu Brown at Mohegan, New York, and are now USNM 55407–8.

The male had its right penis inserted into the female cloaca. The body of the female was somewhat distended anterior to the vent for the length of about six ventrals and the anal plate, the area of the cloaca containing the penis. This region was much harder to the touch than other areas on the ventral surface of the female. The opening of the female cloaca was roughly circular, fitting closely around the narrowed base of the penis.

The sulcus of the penis left the ventral side of the male cloaca, turned through about 45° and entered the female cloaca at the left lateral margin.

Internally the spines of the penis were buried deeply in the walls of the vaginal portion of the female cloaca. The indentations

into which the spines fitted remained even after the cloaca was dissected and the penis removed, although this was certainly caused by postmortem hardening in the preservative. Non-copulating females do not show these pits in the cloacal walls. The penis occupied the posterior three-fourths of the cloaca, and the anterior fourth was filled with a clotted substance, which contained large numbers of spermatozoa.

These sperm were different from those figured by Wilson (1904: 138; this figure was not reprinted in the third edition) for *Coluber*. They showed a rather attenuated acrosome, confluent with the darkly staining head which was sharply truncated posteriorly. The tail was elongate and also confluent with the head. The spiral middle piece in Wilson's drawing could not be resolved in the aceto-carmine smears of this material.

The penis, as noted above, was not applied closely to the anterior end of the vaginal cloaca. It was evaginated through the area of distal large spines and only slightly into the calyculated area. The terminations of the sulcus branches on the outside of the penis were near the openings of the oviducts, but there was no close application as described by Pope. Hemisection of the penis showed that the bifurcated terminus was partially invaginated.

The right penis retractor muscle filled an area comparable to that occupied by the invaginated left penis; as would be expected its diameter was considerably smaller than that of the left muscle. The corpus cavernosum of the evaginated penis was distended with congealed blood.

Certain of these facts are to be expected in the light of Beuchelt's study on the physiology and morphology of the penis in snakes (Beuchelt, 1936). His theory concerning evagination may be summarized as follows:

1. The retractor muscles and the penial musculature are relaxed under nervous control; concomitantly blood pressure is increased in the corpus cavernosum, partly as a result of the muscular spasms of the posterior body wall (also described by Gloyd, 1947 and Davis, 1936). This relaxation of the penial musculature and blood engorgement causes the evagination of the basal portion of the penis.
2. The middle and terminal pieces of the penis are evaginated next as a result of further engorgement caused by the damming of the exits of the corpus cavernosum. Funnels of connective tissue in the vessel walls mediate this damming process.
3. The final phase of evagination is a stiffening and some widening of the penis which is the result of maximal engorgement of blood in the corpus cavernosum, and a concentration of cellular elements in the corpus by suction of plasma from the corpus into the lymph hearts.

Beuchelt has concluded from his studies that the penis is inserted into the female cloaca in stage 1, a "half-tumescent condition," and that complete evagination is accomplished after the basal spines have become anchored. During copulation the enlarged basal spines would first be directed distally, and as the penis evaginated still farther, they would turn through at least 90°, becoming more firmly anchored in the cloacal walls with continued evagination. The spines of a free penis would turn through almost 180° and would be directed almost basally.

Thus, evagination of the penis can be viewed as a primarily mechanical process: the increase of blood pressure forcing the penis outward, turning it inside out, and inflating it like a balloon. In view of these considerations one must re-examine data bearing on mechanical isolation in these organisms. If, as Beuchelt suggests, the penis is inserted in a half-tumescent condition and inflation is completed only after contact is made, it seems probable that the inflatable penis would tend to take on the shape of the vaginal cloaca of the female, much like a balloon that is blown up inside of a box will tend to take on its shape. This, of course, would be within the limits imposed by the morphology of the penis itself.

Pope has cited the examples of *Trimeresurus albolabris* Gray and *T. stejnegeri* Schmidt as sympatric sibling species which are differentiated primarily on the basis of penial structure, and may be isolated mechanically. It would seem, however, that cross-fertilization might not be impossible despite the character differences between the penes and the vaginal cloacae. According to Pope, *T. albolabris* has a long, slender, aspinous, deeply bifid penis, whereas *T. stejnegeri* has a shorter, thicker, spinous, less deeply forked one. The cloacae are comparable: in the former it is long, deeply bifid, and thin walled; in the latter thick walled, short, and with shorter lobes. Pope suggests that "... the long spines of *T. stejnegeri* would probably do considerable damage to the delicate walls of the *T. albolabris* cloaca." But, even though damage be done to the cloaca

of *albolabris* in the event of a male *stejnegeri* × female *albolabris* mating, copulation might still be effective if injuries to the female were not fatal, and if genetic isolating mechanisms were lacking.

Mechanical isolation has received considerable attention from biologists in the past; more recent authors (Goldschmidt, 1940; Dobzhansky, 1941; Jeannel, 1942; Mayr, 1942), on the other hand, tend to discount its importance. The so-called "lock-and-key" theory of Dufour was developed in the study of insects. In such groups with a fixed adult size and presumably relatively invariable structure of the intromittent organ, the mechanism might be of some importance. Jeannel, however, after a discussion of aedeageal differences in insects concluded that they are "*. . . l'effet et non la cause d'un isolement*," and both Goldschmidt and Dobzhansky have pointed out that these differences are frequently insufficient to preclude cross-mating. The latter situation apparently obtains in many related species of snakes. *Heterodon platyrhinos* Latreille and *Heterodon nasicus* Baird and Girard are sympatric over a portion of their respective ranges and their hemipenial architectures are quite similar (Edgren, 1952); it seems unlikely that interspecific mating would be inhibited mechanically in view of the morphological similarities of the penes and their inflatable nature. The entire question of mechanical isolation in snakes should be re-evaluated, bearing in mind the total biology of the species pairs concerned.

Admittedly cross-breeding is probably rare under natural conditions, and even in captivity. Certainly many forms that could cross-copulate never do in the wild because of psychological factors. Noble (1937) has summarized data bearing on this problem, and discussed the influence of sense organs in copulation. Such ethological factors would seem much more important in maintaining species integrity than the morphological differences between the sex-organs.

Many problems still remain to be solved before our knowledge of copulation in snakes and its evolutionary significance can be considered as anything but fragmentary. The relationship between the penis and the vaginal cloaca certainly requires further investigation. In *Liophis*, studied by Pope, the relations were very intimate, and certain other forms show morphological similarity or correlation between the penis and cloaca that could hardly be causally unrelated. In the *Heterodon* discussed here no such intimate relationship existed, the penis filling only about three-fourths of the cloaca. This, of course, is negative evidence and may represent a post-mortem artifact. Further information is needed before any generalizations can be valid; however, the "lock-and-key" hypothesis certainly seems untenable for snakes.

I am indebted to Drs. Remington Kellogg and Doris M. Cochran of the United States National Museum for permission to dissect the specimens described above; and to Dr. F. M. Sturtevant of G. D. Searle and Co., Clifford H. Pope and Dr. Howard K. Gloyd for many helpful suggestions.

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Anaesthesia for Reptiles

C. W. Brazenor and Geoffrey Kaye

THIS paper describes the administration of anaesthetics to certain Australian snakes and lizards. Since the literature is almost silent upon the subject, the writers are led to report their limited experience, both for the information of others and as an amusing byway of anaesthesia.

The National Museum of Victoria is assembling a representative display of casts in latex of Australian reptiles. These casts must be prepared from living specimens, because those prepared from dead ones are not satisfactory. Further, if the reptiles die, the artist who colors the casts cannot reproduce the normally iridescent hues of life.

The Museum's original technique was to place in the reptile's box a swab heavily charged with ether. In about an hour, when the creature had become inert, it was removed and eveloped in plaster-of-Paris. Venomous snakes survived this process more often than not; non-venomous snakes and lizards succumbed without exception. Many choice specimens were thus lost and, with them, the opportunity of coloring their casts from life.

The Museum therefore decided to enlist the aid of an anaesthetist. The latter consulted the Departments of Pharmacology and Physiology at the University and searched the literature of anaesthetics for the past decade; he found, however, scarcely any practical data. Experimentation had therefore to be carried out from the beginning. This paper gives its results.

Experiments on Snakes

Anatomical Considerations.—The anatomy of the snake is highly specialized. Its trachea is long and narrow, extending over the cranial fifth of its body. The glottis is freely mobile from side to side and is situated at the front of the mouth where it is readily accessible for intubation. The right lung is a delicate, fusiform tube which occupies the second fifth of the body. It merges distally into the peritoneum and is easily ruptured by ungentle attempts at artificial respiration. The left lung is rudimentary. There is no diaphragm.

Physiological Considerations.—A snake has but limited cerebral development and is largely a spinal animal. Its metabolic rate, although influenced by the external temperature, is comparatively low. From these facts, certain reactions to anaesthesia were predicted from the start and confirmed by subsequent experience. They were as follows: (a) The induction of anaesthesia was likely to be slow; in fact, it required from 20 to 60 minutes, according to the species and to the external temperature. (b) Complete immobility, necessary for accurate casting, was likely to be obtained in a spinal animal only at a plane of anaesthesia which obtunded all spinal reflexes and so approached to obliteration. (c) Anaesthesia of this plane would necessarily entail complete intercostal paralysis, which, in an animal without a diaphragm, implies complete respiratory arrest; the need for artificial respiration was thus foreseen from the beginning. (d) Signs of anaesthesia, other than response to tactile stimulation, could scarcely be expected in the snake, which normally has no visible respiratory movements. (e) The low metabolic rate was likely to be attended by slow elimination of the anaesthetic, compelling resort to artificial respiration in order to wash the anaesthetic vapor out of the blood stream.

The first step was, therefore, a study of reptilian breathing, which is described only sketchily in the zoological literature. An excited snake is capable of raising its ribs and visibly expanding its body, enabling it to hiss or, in certain species, to eject venom. Under normal conditions, however, its respiratory expansion is distributed over a great number of ribs and is not obvious to the view. There are, therefore, no respiratory "signs of anaesthesia" in the snake. Its intake of oxygen and output of carbon dioxide have not been recorded in the literature, to the writers' knowledge. It is hoped, however, to make them the subject of a further communication.

The high mortality in the Museum's earlier attempts was readily explicable. The reptiles were given ether until all spinal reflexes, and hence all respiration, were abolished. They

were then enveloped in plaster, in which they could not breathe. On removal, no attempt was made to flush the anaesthetic from their blood stream and thus to restore respiratory movements. It is not surprising that, under such conditions, even the long-enduring reptilian heart eventually failed. It was hence anticipated that, if the reptile were given a reserve of oxygen before its envelopment in plaster and artificial respiration immediately upon its removal, it should have good prospects of survival. This anticipation was borne out by results.

ANAESTHETIC TECHNIQUE.—The agent chosen was ether, which is easily given, potent, but yet not unduly toxic. Chloroform had been noted previously, by both writers independently, to have an apparently convulsive effect upon snakes. Gaseous anaesthetics were excluded by their swift elimination, which might have set awkward problems in the control of partially recovered, resentful and venomous subjects. It is probable that agents other than ether would answer perfectly well. The object of the study, however, was not to arrive at the optimal anaesthetic for snakes; it was to devise a technique for the problem immediately on hand.

In the first experiments, known percentages of ether-vapor were delivered into the reptile's box from an Oxford vaporizer. The highest obtainable percentage (*circa* 25) failed to anaesthetize even a non-venomous snake within 90 minutes. More decisive, if cruder, methods were therefore indicated.

The snake was placed in a glass-fronted wooden box, made reasonably airtight and having a small hold in its lid. Through this hole, 30 milliliters of ether were injected by syringe on to the wooden floor. Further increments of 10 milliliters were added as required to obtain a progressive march into anaesthesia. The snake's first reaction was to crawl away. Failing in this, it would hold its head clear of the pool of ether-vapor on the floor of the box. When unable longer to maintain this posture, it would bury its head in its coils. If stirred with a rod passed through the aperture, it would again try to escape. After 20–30 minutes, according to species and external temperature, the snake would become torpid and could be pushed stiffly across the box. If removed at this stage, it might recover quickly and offer to strike, although it was too incoordinate to do so effectively. If left in the box for a further period, however, it would become inert and lie motionless when removed to the bench. Care was taken not to leave it in the box for longer than was absolutely necessary to produce inertia.

On removal, the snake was fitted with the hood (Fig. 1) which precluded biting and facilitated further administration of the anaesthetic. The plane of anaesthesia was now tested in two ways: (a) by running a finger down the snake's back, when it might elevate its ribs, and (b) by squeezing it in the region of the

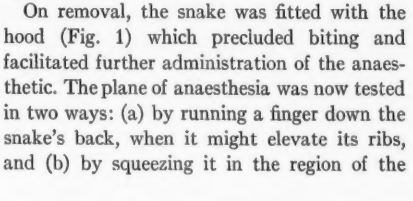

Fig. 1. Diagram of apparatus used in anaesthesia and resuscitation of snakes and lizards. A, balloon, 65–100 ml. capacity; B, aperature, ¼–½ inch diameter; C, oxygen inlet; D, hood, ¾–1½ inch external diameter; E, finger stall or small balloon; F, cellulose tape.

vent, when it might move its tail. If these signs were positive, molding was still impracticable, lest the smake move under the plaster and blur the impression. Accordingly, a small balloon, containing a pad charged with 3 milliliters of ether, was slipped over the free end of the hood and filled with oxygen by means of the side-tube. This reproduced the conditions of the closed box, but with better control and better opportunities for observing the signs of anaesthesia.

Flaccidity and loss of all spinal reflexes now supervened, usually within a few minutes. The snake's lung was inflated two or three times by gentle pressure upon the balloon, so as to provide a reserve of oxygen for the molding process. Unduly deep anaesthesia could be reversed by a few similar inflations with pure oxygen. When the plane of anaesthesia was deemed satisfactory, *i.e.*, when pressure near the vent just failed to evoke movement of the tail, the hood was removed, the snake was posed realistically and plaster was applied.

When, after 10–15 minutes, the mold had set, it was turned over and the snake's head was at once extricated. Reflex movement might or might not be present. Venomous snakes might be fairly active; non-venomous ones, flaccid and seemingly defunct. They could be resuscitated, however, by prompt "de-etherization." The nostrils were freed of plaster, the jaws separated, and a short length of polythene tubing placed in the mouth to serve as an airway. A clean balloon filled with oxygen was fitted to the hood and the latter was reapplied. Rhythmical inflations of the snake's lung were then commenced, about twice in each minute. The balloon was of the thinnest and the pressure upon it was never more than would produce visible expansion of the cranial two-fifths of the snake's body; excessive pressure might well cause rupture of pulmonary alveoli. On a few occasions, inflation was seen to be ineffective; the largest applicable polythene tube, from 1 to 3 millimeters in diameter, was then passed as an endotracheal airway. It made inflation very easy, but necessitated extra gentleness, if the alveoli were not to be injured.

Reflex movements usually returned after a few inflations and were seen followed by a return of motor power. In the meanwhile, the snake's body was freed from the mold, its neck was held securely and its hood was removed. It was given a tepid bath to free it from plaster and was returned to its now-ventilated box.

Visible, deep breaths were frequent during the phase of recovery, in contrast to that of induction. Lung-inflation was always continued until these, or active somatic movements, were apparent. Some snakes relapsed, for no obvious reason, into lethargy. Anxiety was not felt if they could still breathe spontaneously, had tone in the cervical muscles, and could flicker the tongue. If left alone, they would eventually emerge from lethargy and move, at first uncertainly but soon with full mobility. Attempts to stimulate movement by means of a warm bath were found to be undesirable. The warmth raised the metabolic rate at a time when the snakes were ill-adjusted and was often followed by prostration.

The use of oxygen for the resuscitation of creatures of low metabolic rate is open to theoretical criticism. To forestall this, a large tigersnake was left for 30 hours in an atmosphere containing 98 percent of oxygen, as shown by a Beckman paramagnetic analyzer. The snake was removed in a condition which could be aptly described as a fighting fit. The brief exposure of the anaesthetized snakes to an atmosphere rich in oxygen was, therefore, presumably innocuous.

Experimental Results. Fourteen experiments were performed upon snakes, in which at least one example of each of the following species was anaesthetized, molded and resuscitated: *Notechis scutatus*, tigersnake; *Python spilotes variegata*, carpetsnake; *Liasis olivaceous*, Northern Territory rock python; *Dendrophis punctulatus*, Queensland golden treesnake; *Boiga fusca*, Queensland brown treesnake; *Typhlops polygrammicus*, blindsnake; *Denisonia flagellum*, little whipsnake; *Denisonia superba*, Australian copperhead; *Demansia textilis*, Australian brownsnake; and *Pseudechis porphyriacus*, Australian blacksnake. It was not possible, during the tenure of these experiments, to obtain living specimens of *Oxyuranus scutellatus* (taipan) or *Acanthophis antarcticus* (death adder). With these exceptions, the series is fairly representative of the Australian snakes.

There was one fatality, in a white-lipped snake (*Denisonia coronoides*) weighing a half-ounce (14 grams). Being so small, it was able to crawl through the quarter-inch hole at the end of the hood and to bury its head in a small puddle of ether in the balloon. It survived casting, but was obviously prostrated. It was ill-advisedly given a warm bath, when it became very active, but soon relapsed into flaccidity and died. It probably suffered from glottic swelling consequent upon its immersion in ether, so that the increased metabolism engendered by the warm bath produced a call for extra oxygen which it was unable to meet.

Of the 14 snakes which survived, the smallest was a baby tigersnake twelve inches (30 cm.) in length and one-half ounce (14 grams) in weight. The largest was a rock python, 9⅓ feet (290 cm.) in length and 8¾ pounds in weight. The non-venomous snakes were, in general, more susceptible to ether than the venomous, and more often in need of resuscitation. The hardiest subjects, and the least agreeable to handle, were the tigersnakes.

One snake, not included in the above series, was the subject of a surgical operation. It was a fine tigersnake, referred by a private collector for excision of a tumour of the back. Anaesthesia was induced in the usual way and was maintained by means of two balloons, one charged with ether and the other not. By alternating in their use, it was possible to maintain a plane at which spinal reflexes were kept just obtunded. Lung-inflation was required throughout the operation, which lasted for 20 minutes. The tumour was reported by the pathologist to the Alfred Hospital (Dr. A. V. Jackson) to be a simple granuloma. Recovery was uneventful, except that primary healing of the wound was not obtained; the snake rubbed off its dressing and reopened its incision.

Experiments with Muscular Relaxants.—It was hoped that the use of muscular relaxants might have proved easier for the Museum's staff than that of ether. Experiments were devised accordingly. The subjects, tigersnakes, were taken behind the head with the snake-stick and withdrawn from their boxes. The tail was steadied and the relaxant was given intramuscularly, low down in the back so as to avoid intravisceral injection. The snakes were then returned to their boxes and developments were observed.

Decamethonium iodide was chosen for the first trials, as being more quickly eliminated (at least in mammals) than is tubocurarine. Four tigersnakes were used, each approximating to 3½ feet (100 cm.) in length and three-quarters of a pound (350 grams) in weight. A dose of 0.05 milligram produced no obvious curariform effect. Doses of 0.5 milligram were lethal. The snakes became immobile in from 15 to 30 minutes and then developed tetaniform contractures which drew the body into sharp angulations. These were presumably due to the depolarizing effect of the relaxant upon the neuromuscular end-plates. Complete flaccidity then supervened. Lung-inflation with oxygen, through an endotracheal tube, led to reversion to the tetaniform condition. After this alternation had continued for hours, the snakes were allowed to die. Even after death, their bodies retained angulation.

A dose of 0.1 milligram of decamethonium (*i.e.*, 0.25 milligram per kilogram of bodily weight) was followed by recovery in the one snake which received it. Paralysis, which began after 35 minutes, was of the spastic type with marked angulations of the body. It was never complete, the head and an inch or two of neck remaining active and striking on any provocation. For this reason, it was not thought judicious to apply a hood, but the box was filled with oxygen. Recovery ensued during the night, so that its progress was not observed.

When relaxants are given to snakes, a misleading idea as to bodily activity arises if they be retained in their boxes. Being cramped, they tend to move their aggressive end rather than to escape. They may thus appear to become paralyzed from the tail upwards. A fairer test consists in placing the snake on the floor. The time for removal can be judged by hooking the tail through the door of the box. If the tail be paretic, the snake can be withdrawn bodily without undue risk and placed upon a smooth floor, where it can move freely without being able to travel far.

Six tigersnakes, roughly comparable in size to the foregoing, were given tubocurarine chloride. Of these, four were used to establish the minimal curarizing dose, which proved to be of the order of 6 milligrams per kilogram of bodily weight. This is twenty-six times the usual human dosage which is 0.24 milligram per kilogram. One snake became helpless after receiving only 3 milligrams per kilogram, but too much must not be inferred from this, because it had a sore back in consequence of injury during capture. The sixth snake, a fine specimen, received the full six milligrams per kilogram. Paralysis began to appear after 72 minutes and affected head and tail synchronously. Thirteen minutes later, the snake was incapable of movement. After a further fifteen minutes, it required artificial respiration, which had to be continued for a half-hour before it was able to fend for itself.

One small python, about four feet in length, was found to require tubocurarine in a dosage of 1.8 milligrams per kilogram of bodily weight. After 55 minutes, it was placed on a table, where it soon lost the power, although apparently not the willingness, to strike. Strokes occurred progressively in "slow-motion" time, with ever greater difficulty in regaining the striking position. Five minutes later, the snake was helpless; its oral mucosa was cyanotic and

it needed artificial respiration. This had to be continued for 40 minutes before the snake could fend for itself. The smaller dosage of relaxant required by this python, as compared with the tigersnakes, paralleled experience with ether.

The resistance of snakes, and especially of venomous snakes, to muscular relaxants is striking. Its explanation is a problem for the comparative pharmacologist. The Australian colubrines have been shown to have high immunity to the venom of their own and related species. That venom appears to exert a curarizing action upon man. Whether these facts may account for the high resistance of colubrine snakes to curare, and to its ally decamethonium, is not known to the present writers.

The muscular relaxants do not seem to be applicable to the Museum's immediate purposes. Firstly, the snake is conscious, although helpless, and must not be hurt. Secondly, it is difficult to estimate the proper dosage, and failure in this respect will leave the snake with enough muscular power to strike. Thirdly, the time of elimination is inconveniently long. Finally, decamethonium is useless because it produces angulations which give the body an unnatural appearance, unsuitable for molding.

Experiments on Lizards

Anatomical and Physiological Considerations.—The lizard has paired lungs and its trachea is much shorter than that of the snake. Like the latter, it has no diaphragm. Its intercostal respiration is, however, visible both at rest and during anaesthesia, of which it thus provides a recognizable "sign."

Anaesthetic Technique.—The technique evolved for snakes was applied also to certain lizards. Induction was effected in a closed container. The quiescent reptile was then placed in the hood already described and anaesthesia was deepened until pressure near the vent evoked no movement of the tail. At this stage, spontaneous respiration was obliterated. The lungs were therefore inflated with ether and oxygen; the hood was removed and the lizard was enveloped in plaster. When the latter had set, the lizard's head was freed and artificial respiration with oxygen was commenced. Lizards appeared to be more delicate than snakes and to stand in greater need of resuscitation, the more so because the freeing of their limbs from the mold was a slow process. They were prone, for a reason unknown, to relapse into apnoea and flaccidity after having regained the power of locomotion, and had to be resuscitated a second time.

Experimental Results.—Six experiments were performed upon lizards, in which at least one specimen of each of the following species was anaesthetized with ether, molded and resuscitated: *Diplodactylus spinigerus*, spinytailed gecko; *Gymnodactylus platurus*, leaftailed gecko; *Amphibolurus muricatus*, treedragon; *Egernia cunninghami*, Cunningham's skink; and *Tiliqua scincoides*, common bluetongued lizard. There was no fatality in the series. The smallest lizard was a gecko, weighing one-seventh of an ounce (4 grams).

A thick-tailed gecko (*Gymnodactylus miliusi*), not included in the above series, was nearly the victim of oversight. Anaesthesia was being induced in a large copperhead snake when it was discovered that the gecko was sharing its cage. Rather than open the latter and separate the gecko from the excited snake, events were left to take their course. When the snake became incoordinate, the gecko was removed from beneath its coils. Weighing only a quarter-ounce (7 grams) and having been exposed to the same anaesthetic atmosphere as the powerful snake, it emerged as flaccid as a gecko could well be. Its lungs had to be inflated with oxygen for a half-hour before spontaneous breathing returned.

A Cunningham's skink, weighing 6½ ounces (186 grams), was given 0.17 milligram of tubocurarine. This represented a dosage of 0.9 milligram per kilogram of bodily weight, or half that received by the python already mentioned. Complete flaccidity, necessitating intubation of the trachea and artificial respiration, supervened within 18 minutes. Spontaneous breathing returned 42 minutes later, but the lizard was not regarded as fit to look after itself for a further 36 minutes.

Summary

Anaesthesia in reptiles, which have no diaphragm, necessarily involves respiratory arrest and enforces a technique of artificial respiration.

A suitable anaesthetic technique using ether is described. It is doubtless applicable to other inhalational anaesthetics.

Fifteen snakes, of eleven species, were anaesthetized, molded in plaster-of-Paris and resuscitated, with one accidental fatality. One snake was anaesthetized for a surgical operation.

Six lizards, of five species, were anaesthetized, molded and resuscitated without fatality.

Muscular relaxants were administered successfully to several snakes and one lizard. The technical problems involved are discussed. The dosage of relaxant needed is up to twenty-six times the human dosage per kilogram.

NATIONAL MUSEUM OF VICTORIA, AND UNIVERSITY OF MELBOURNE, MELBOURNE, AUSTRALIA.

An Ecological Survey of the Herpetofauna of the Grand Teton–Jackson Hole Area of Wyoming

CHARLES C. CARPENTER

THE purpose of the following survey was to determine the species of reptiles and amphibians present in the Grand Teton–Jackson Hole area of Wyoming, and to gather ecological data related to them. The area surveyed included the regions bounded by the Teton Mountain Range on the west and the Absorka Range on the east, and extending from the north end of Jackson Lake south to the junction of the Snake and Hoback rivers. Field trips were planned to sample the various habitats within the region. Evidence for the presence of a species was obtained by the following: searching on foot, road surveys, traps, seines and nets, and evidence from shed skins, from food records and from larval forms.

This study was made possible by a grant-in-aid from the New York Zoological Society for work at its Jackson Hole Research Station during the summer of 1951.

AMPHIBIANS

Ambystoma tigrinum melanostictum (Baird).—This is the only salamander known in the area and it is generally distributed over the entire region. Large and newly transformed adults, large and small larvae, and axolotls were observed and collected throughout the summer. The types of bodies of water containing larvae and adults varied greatly. On only one occasion was a larva found in a body of water with fish, and this was in a slough where the larva could have readily entered from other nearby bodies of water. This form was collected from beaver ponds, pot holes, stagnant flood pools, temporary pools, mountain pools, open meadow pools, and an artificial lake. Larvae were observed in mountain pools above 9,000 feet, in forested areas.

The adult salamanders were difficult to locate, and none was discovered by turning over hundreds of logs, stones, and other types of cover. Funnel traps were used to obtain many adults. The traps consisted of cylinders of ¼-inch mesh hardware cloth, 8 and 10 inches in diameter, and 24 inches in length; cones of the same hardware cloth, with a 1-inch opening at the apex, were inserted into each end of the cylinder. These traps were placed in ponds and other aquatic habitats at varying depths and at different distances from shore, with the long axis of the trap parallel to the shore line. Excellent results were obtained when the traps were set out in the evening and checked the following morning, but results of day-time trapping were poor. Both larvae and adults were captured in this manner. Attempts to observe the activities of the adults late at night, by walking along the shore with a spot light, were unsuccessful.

The only times that adults were collected on land were during or immediately following rain storms. By driving along paved roads during rain storms, using the car spotlight, one could readily catch the glint of frogs, toads, and salamanders crossing the road. Those

captured varied from the smallest observed transformed individual to large adults. A surprising result brought out by this method was that the largest numbers were observed on a road that was bordered by sage flats, the driest and seemingly most unsuitable type of habitat for salamanders. During dry weather it was impossible to locate any individuals on these flats, but as soon as a heavy rain occurred, there were many salamanders crossing the road. It is probable that a very large number of individuals of this species live most of their lives on these sage flats, down in the numerous rodent burrows, and that they emerge only when the surface of the ground is very wet. To test for movement about these flats at night, funnel traps with drift fences leading to them were set, but all results were negative.

Some adults were captured along roads bordered by aspens, but none was taken in areas bordered by conifers.

Axolotls were never obtained alive, although a number of them were taken as beach drift along the shores of an artificial lake (Tracy Lake). This lake also contained transformed adults and small larvae.

Adults collected from aquatic habitats averaged larger than the adults taken on land during the road surveys. The largest adult female captured measured: total length, 200 mm.; tail, 91 mm.; head length, 30 mm.; and head width, 26 mm. The largest male measured: total length, 233 mm.; tail, 115 mm.; head length, 32 mm.; and head width, 25 mm. The smallest transformed individual, captured crossing the road in the rain, measured: total length, 85 mm.; tail, 33 mm.; head length, 12 mm.; and head width, 10 mm. The latter specimen was much smaller than many of the larvae captured in the region.

At any one time during the summer a great variation in the size of the larvae in different ponds existed. Perhaps the variations in size of larvae and in size at transformation arise from differences in breeding time and also from differences in food supply.

Some idea of growth of this species can be obtained from the following observations. On July 4, a series of 10 larvae was collected from an open gravel-bottomed pool with little vegetation, near the Snake River at Moran. This series averaged 56 mm. in length. The individuals were placed in an aquarium for the summer and were not fed. When they were preserved on August 20, measurements registered no appreciable growth. On August 20, another sample was obtained from the same pool. The three individuals captured, which very probably represented the population originally sampled, average 135 mm. in length; their tails had lost their larval character; and the gills were no longer functional, but were small stubs 2 and 3 mm. long. These individuals, nearly completely transformed at approximately 135 mm., and the smallest transformed specimen (85 mm.) mentioned above, indicate an extensive size range for this phenomenon.

On August 16, a large concentration of salamander larvae was observed in a quarter-acre pool in which vegetation was abundant. The pool was located in an area of open, grass-covered hills, the nearest woods being about one mile distant. The larvae were not scattered over this small pool, but were in aggregations of from 10 to 50 in the shallow water, especially near the bases of willows along shore. When disturbed, they would quickly scatter, but in a few minutes would return to form another aggregation. A series of 24 which were collected averaged 114 mm. in length, and still had large gills and prominent tail fins.

Coloration of individuals varied from predominantly yellow in some to almost entirely black with an obscure pattern in others. Large specimens, particularly those taken from aquatic habitats, were lightest in color.

More than half of the waters in which this salamander was found contained large populations of leeches, and I have gathered evidence that these ectoparasites prey extensively upon the adult and larval salamanders. At Tracy Lake, where the leech population was large, funnel traps were set in shallow water. When they were checked in the morning, the traps were swarming with leeches, as many as 35 to a trap, and all the imprisoned salamanders were dead. Most of the leeches were clinging to the gular regions of the salamanders. Dead axolotls which were picked up as beach drift had leeches attached to them. Small larvae, seen swimming near the shore in this lake and in other ponds, often had large leeches clinging to the gill region; and their usually swift

movements were impeded by the presence of these worms. Some small larvae had as many as four leeches attached to them, while a few larvae were observed dead along the shore which was swarming with leeches; the larvae presumably had been killed by these parasites. When specimens of salamanders were preserved, many small leeches, not seen before, released themselves from their prey.

An adult salamander was observed in the stomach contents of a badger, which also included 6 adults of *Bufo boreas boreas*.

Bufo boreas boreas (Baird and Girard).—This is the most wide-spread amphibian in the region—it is found in almost every locality and in a great variety of habitats. This toad shows a definite preference for aquatic situations. It is partial to the banks of streams, pools, sloughs, and lakes; and it will readily hop into the water and dive to the bottom for security.

A few individuals were captured at Togwotee Pass, elevation 9658 feet; and one individual was collected in the upper valley of Death Canyon, high in the mountains.

The larvae of this species were found in a variety of habitats, ranging from river flood pools with little or no vegetation to large lakes. On July 7th, on the west shore of Jackson Lake, a group of tadpoles was seen beneath extensive rafts of drift wood where the water depth varied from one to three feet. Schools of minnows were near by, but they did not seem to be attracted to these tadpoles. A sample of seven individuals had the following average measurements: total length, 11.8 mm.; body length, 5.1 mm.

Between August 3 and August 18, the following observations were made on tadpoles of this species in a flood pool on Pacific Creek. This one-half-acre pool had no vegetation. On August 3, a large number of tadpoles was noticed in the pool; some were resting near shore, others swimming parallel to it about three feet out. A series of 19 collected on this date had the following average lengths: total length, 31.8 mm.; body length, 13.9 mm. They had small hind legs, but none was observed to yet have front legs.

On August 14, many individuals with four legs were seen, but some had only the two large hind legs. None was observed leaving the water. On August 18, four were found which had almost completely lost their tails and were out of the water, but the majority were in various intermediate stages: some with hind legs only, and many with four legs but still much of the tail remaining. These intermediate stages tended to remain aggregated along little notches of the shore, and when disturbed, all moved away in the same general direction. At one small notch (2 feet square and 2 to 3 inches deep) which was isolated from the main pool by a dike of sand, the majority of those collected had four legs and were well along in their transformation. It was here that the four that had left the water were found. The greater part of my sample was taken from this place so that the remaining animals were much disturbed. On returning to this spot after a few-minute interval, I found that those remaining individuals, still with most of the tail present, were leaving the water and climbing the dike that separated them from the main pool. They did it very awkwardly, but all left on the side nearest the main pool and progressed in spurts over the dike to reach it. It was surprising to me that individuals with such large tails would leave the water and that they were able to go directly to the main body of the pool. That the individuals farthest along in development were from the small isolated pool may indicate a different water chemistry in the two situations. Of the samples collected on this date, a series of seven, with no front legs, but with large hind legs, and with no pattern of glands yet apparent, had the following average measurements: total length, 38 mm.; body length, 16 mm.; a series of 23, with four legs and varying amounts of tail (three with tail completely lost), and with patterns of glands apparent on all four-legged individuals, had the following average measurements: total length, 25 mm.; body length, 14 mm. From this it is evident that the gland pattern appears at about the same time that the front legs do. On August 20, it was evident that many had transformed and had left the pool during the previous two days. A small boy who lived near by mentioned having seen many small ones hopping away. The majority of those still in the pool had four legs but there were still some with the hind legs only.

Pseudacris nigrita triseriata (Wied).—This secretive form is more abundant in the area than I had suspected. In early summer, cho-

ruses may be heard from Moran up to Togwotee Pass at about 10,000 feet elevation. The choruses probably start later and persist longer at the higher altitudes.

On July 15, a breeding chorus of this species was heard in an open, mountain meadow at Togwotee Pass. The frogs were in small, flooded holes scattered over the meadow. The majority of the calls were typical for this species; yet another call was present, a short whistle, somewhat similar to the call of *Hyla crucifer*. It is uncertain that this call was produced by *Pseudacris*, but none of the other frogs of the area seems a more likely contender.

During a road survey on the rainy night of July 28, three adults and one newly transformed individual were collected crossing the road in areas where there were low damp meadows.

On August 9, at a small roadside marsh near Driggs, Idaho, about one mile west of the Teton Mountains, hundreds of individuals were observed in all stages of transformation. The following measurements were taken from a series collected at this marsh.

Specimens with hind legs only, or with hind legs plus one front leg only:
Number of specimens, 20.
Body length: average, 15.55 mm.; range, 15–16.5 mm.
Total length: average, 41.18 mm.; range, 39–45 mm.
The adult color markings and pattern were not as yet apparent.
Specimens with four legs, and with tail longer than 20 cm.:
Number of specimens, 7.
Body length: average, 16.24 mm.; range, 15–17.2 mm.
Total length: average, 39.71 mm.; range, 37–42 mm.
The adult color markings and pattern very faintly visible, and the two color phases distinguishable.
Specimens with four legs, and with tail of medium length (5 to 20 mm.):
Number of specimens, 19.
Body length: average, 16.69 mm.; range, 16–18.5 mm.
The adult color markings and pattern faintly visible, and the two color phases readily distinguishable.
Specimens with four legs, and with a stub tail (2–3 mm.):
Number of specimens, 10.
Body length: average, 16.83 mm.; range, 16–17.6 mm.
The adult color markings and pattern very prominent, the two color phases very distinct.

The two color phases, brown and green, were observed not only in this transforming population, but also in samples from other areas. There does not appear to be any intergradation; that is, specimens are either a definite brown or green, and the two colors appear in about equal numbers of the individuals observed. As indicated above, the color and typical pattern of the species become evident at about the time that all four legs are present on the tadpole.

Rana pretiosa pretiosa (Baird and Girard).—This is the most abundant frog in the region; but, unlike the toad, it is restricted to the water margins of streams, pools, creeks, marshes, sloughs, and lakes, both in the woods and in open meadows. This species ranges up to Togwotee Pass at 9680 feet. During rainy-night road surveys, this frog was taken only on the roads bordered by bodies of water.

The larvae are found in varied aquatic situations. On July 20, a transformed specimen measured 25 mm. in body length, while a tadpole in the pool nearby with large hind legs measured only 23 mm. On July 8, a series taken near Moran averaged 22.4 mm. in body length and 57.8 mm. in total length. On July 22, in a mountain pool 3 miles west of Togwotee Pass (approximately 9000 feet), a large aggregation of tadpoles averaged 16.2 mm. in body length and 44.5 mm. in total length. These tadpoles had very small hind legs.

Rana pipiens (Schreber).—This species was observed in only two localities in the region. At String Lake it is common along the grass-sedge shores where it is closely associated at times with *Rana p. pretiosa*. No individuals were observed on Jenny Lake or Leigh Lake, both of which connect with String Lake. One individual was observed along the banks of the Teton River between Driggs and Victor, Idaho.

Reptiles

Thamnophis sirtalis parietalis (Say).—This snake is generally found near some body of water and is most abundant along the gravel flood plains of the streams of the region. Occasionally it is observed wandering through meadows.

On July 12, on a river flood plain, four gravid females were observed sunning themselves next to a rotten drift log. The opening of a burrow (1½ inches in diameter) was found

beneath the log, and presumably the burrow served as a den for these snakes. The body lengths and total lengths of these four females ranged from 62 and 80.4 cm. to 66.5 and 85.8 cm.

Of five individuals recorded with food, two had eaten *Bufo b. boreas*, two had fed on *Pseudacris nigrita triseriata*, and one contained fish bones.

Thamnophis elegans vagrans (Baird and Girard).—This gartersnake was found less frequently along the stream flood plains than was the former species; however, both species were found together near pools and marshes. Unlike the red-sided gartersnake, it occurs out on the flats, at long distances from water, and was taken along the base of talus slopes at the foot of the mountains. One individual was taken by funnel trap 200 yards back from the lake shore in the dense coniferous forest at the foot of the Tetons. Two gravid females were captured while sunning themselves on the rocky, bushy side of a glacial moraine. The body lengths and total lengths of the two females were: 61.2 and 78.9 cm. for one, and 67 and 86 cm. for the other.

Of the five individuals that contained food, two had eaten leeches, one had eaten a *Pseudacris nigrita triseriata*, one a *Bufo b. boreas*, and one a small fish (*Cottus* sp.).

Evidence of Other Species

Pituophis catenifer sayi (Schlegel).—Individuals of this species were not collected, but there seems to be good evidence for their presence in the Hot Springs area just south of the junction of the Snake and Hoback Rivers. According to the present proprietor of the Hot Springs, the original homesteader of the area kept these snakes as pets and they were quite plentiful at that time. Individuals were said to have been seen on two occasions during the summer of 1951. A local resident of the area said that they were quite common at one time around the farm where she lived.

Charina bottae utahensis VanDenburgh.—One specimen was examined and photographed in Death Canyon by H. W. Levi and L. R. Levi on August 4, 1950. A conversation with H. W. Levi revealed that this specimen was observed in the damp coniferous area at the base of the canyon. He saw the tail going beneath a log and captured the snake. In handling it, he noticed the prehensile tail; and he later verified the identification of the species by comparison with pictures in the literature.

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Records of Pleistocene Reptiles from California

Bayard H. Brattstrom

While working on the Pleistocene amphibians and reptiles from Rancho La Brea, an opportunity to examine some material from other Pleistocene localities in California was made through the courtesy of Dr. Charles L. Camp, Museum of Paleontology, University of California and Dr. Hildegarde Howard, Los Angeles County Museum.

This additional material comes from three main localities, Potter Creek Cave in Shasta County, Hawver Cave in El Dorado County and the McKittrick Asphalt in Kern County, California. The material has been compared with skeletons of recent species in the writer's collection together with a few skeletons in the Museum of Vertebrate Zoology, University of California.

List of Species

Potter Creek Cave.—***Crotalus potterensis,*** sp. nov.

Hawver Cave.—*Crotalus viridis, Elgaria multicarinata, Sceloporus graciosus.*

McKittrick Asphalt.—*Sceloporus occidentalis, Gambelia wislizeni, Eumeces gilberti, Cnemidophorus tigris, Pituophis catenifer, Lampropeltis getulus, Crotalus viridis, Clemmys marmorata, Gopherus agassizi.*

Potter Creek Cave

Potter Creek Cave is located on Potter Creek, about 1 mile east of Baird in Shasta County, California. The locality lies today in the Lower Transition Life Zone at an elevation of 1500 feet above sea level. The surrounding country contains primarily conifers, oaks and maples, with shrubs forming thickets in less favorable exposures.

The report of Sinclair (1904) in discussing the exploration and geology of the cave constitutes the first published record of a Pleistocene *Crotalus* from this cave. The material forming the basis of this record includes two vertebrae; and due to the large size of the centrum, both in diameter and in length, this snake is described as a new species.

Crotalus potterensis, sp. nov.

Type.—University of California, Museum of Paleontology No. 3129, consisting of two vertebrae, a part of a pterygoid, fragments of ribs, and three other fragments of bones.

Occurrence and age.—Potter Creek Cave, Shasta County, California, Late Pleistocene.

Diagnosis.—A *Crotalus* characterized by the presence of a centrum which is large both in diameter and in length.

Description of type.—The type specimen includes two mid-thoracic vertebrae with the following measurements (in millimeters):

	No. 1	*No. 2*
Length of centrum	7.5	7.1
Height of centrum	3.7	2.9
Width of centrum	3.7	3.4
Width at postzygapophyses	11.4	—
Width of postzygapophyseal process	2.7	2.7
Width of prezygapophyseal process	2.8	—
Width of neural spine	4.6	5.6
Height of neural canal anteriorly	1.5	1.4
Width of neural canal anteriorly	2.5	2.4
Width across zygosphene	4.4	4.3
Height of zygosphene from top of centrum	2.5	2.9

The neural spine and hypapophyses are broken on both vertebrae (Fig. 1).

The pterygoid contains six sockets, and in two of them the teeth have remained. The teeth are short and wide at the base, similar to *C. viridis*, and not elongate and thin like those found in the *atrox* group. The pterygoid is larger than any in the *viridis* or *atrox* groups. The fragments of ribs and other bones are not in sufficiently good condition to provide reliable measurements.

C. potterensis was probably most closely related to the *viridis* group and it may well have been either a lateral branch of *viridis* or ancestral to it at a time just prior to the differentiation of *viridis* into its subspecies. The vertebrae are not so large or so wide as those of *Bothrops* and *Agkistrodon*, and, as a study of the comparative osteology of the Crotalidae and especially the species of *Crotalus* and *Sistrurus* is in process by the writer, a detailed discussion of these differences will be presented therein.

As indicated by the size of vertebrae of this individual, *C. potterensis* was a large snake and

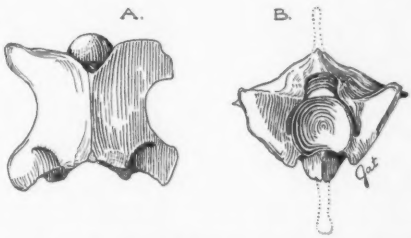

Fig. 1. Vertebrae of *Crotalus potterensis*. A, dorsal view; B, anterior view.

its presence would suggest a warmer climate than that which prevails at the present time (Bergmann's principle, *vide* Cowles, 1945).

As to the age of the Potter Creek Cave, the presence of such extinct genera as *Arctotherium*, *Nothrotherium*, *Megalonyx*, *Euceratherium*, *Platygonus*(?) and *Mammut*, as given by Stock (1918), indicates its Pleistocene age. According to the mammalian faunas, Stock suggested that Potter Creek Cave is a little older than Hawver Cave.

On the basis of rodent fauna, Kellogg (1912) suggested that the region around the cave was more humid at the time of accumulation of the deposits than at present. Today most of the rodents from Potter Creek Cave are Transition or Boreal in their distribution.

Except for three extinct species and the preponderance of owls, falcons and vultures, the

avifauna of this cave is similar to that found in the area today (Miller and De May, 1942).

The size trend of modern crotalids, with respect to climates and the large size of the individual represented by this fossil, would suggest a warm period, either interglacial or Late Pleistocene. Because the local geology of the Pleistocene in the western United States is not well understood as yet and because only one specimen is available, the exact age and climatic condition is still a matter of speculation.

The material available from the cave consists of five vertebrae of *Crotalus* and four dentaries of lizards.

The *Crotalus* vertebrae (Table I) agree in proportions and measurements with *Crotalus viridis* and are here referred to that species.

Three of the lizard dentary bones can be referred to *Elgaria multicarinata*. Two of them measured 12.9 and 12.8 mm. long, compared with 14.4 mm. for a large specimen of *E. m. webbi*. Both of these fossil dentaries contained 20 teeth (or sockets), whereas *E. m. webbi* contains up to 24 teeth. The third dentary which is referable to *Elgaria* is a fragment measuring 9.3 mm. long. Both of the larger fossil dentaries are larger than those of *E. caeruleus shastensis*, *E. c. palmeri* or *E. c. caeruleus* which have their present ranges adjacent to the fossil locality. *Elgaria multicarinata* occurs in the vicinity of the fossil locality today.

TABLE I

SUMMARY OF MEASUREMENTS (IN TENTHS OF MM.) OF *Crotalus viridis*, FOSSIL AND RECENT
(Measurements of recent forms are taken from skeletons of *C. v. helleri* and *C. v. lutosus*)

Measurement	Locality Number of specimens; range (in parentheses) and average of measurements			
	Hawver	McKittrick	La Brea	Recent
VERTEBRAE	5	20	28	5
Height	1 (95)	12 (50–115) 84	14 (62–160) 104	4 (84–129) 103
Width		13 (20–53) 36		3 (48–58) 53
Length of centrum	5 (35–53) 44	20 (21–65) 40	28 (37–70) 57	5 (47–73) 56
NEURAL SPINE				
Height	1 (12)	11 (10–34) 23	21 (12–45) 26	5 (17–30) 21
Width	2 (21–38) 22	10 (20–35) 27	19 (17–60) 35	5 (29–42) 34
PREZYGAPOPHYSES				
Width across	1 (54)	13 (38–99) 62	22 (56–149) 94	5 (84–117) 96
Width of process	2 (12–14) 13	11 (9–18) 13	26 (9–25) 15	5 (6–21) 15
POSTZYGAPOPHYSES				
Width across	3 (41–80) 57	14 (43–90) 60	25 (49–131) 75	5 (78–111) 90
Width of process	4 (10–19) 15	13 (11–19) 14	26 (12–27) 17	5 (15–20) 17
CENTRUM				
Height	4 (14–22) 18	14 (10–25) 17	26 (13–34) 24	5 (23–30) 25
Width	4 (14–27) 21	14 (12–29) 21	26 (12–36) 24	5 (22–32) 23
ZYGOSPHENE				
Width	4 (22–40) 31	13 (19–38) 28	26 (25–55) 38	5 (21–44) 35
Height from centrum	3 (16–24) 20	13 (15–29) 20	26 (15–34) 25	4 (23–29) 27
Width of process	4 (8–18) 13	13 (8–17) 11	27 (8–25) 15	4 (11–20) 15

HAWVER CAVE

Hawver Cave is in El Dorado County, 5 miles almost due east of Auburn, and approximately 150 miles to the southeast of Potter Creek Cave. It is situated to the south of the Middle Fork of the American River at an elevation of 1300 feet above sea level or about 700 feet above the present bed of that river.

The fourth dentary from Hawver Cave is that of a large *Sceloporus graciosus* as determined from the size, shape and position of the mental foramen. It has typical iguanid trifid posterior teeth. From *S. occidentalis* and *S. magister* the fossil can be distinguished by the fact that the portion of the dentary just posterior to the teeth is raised gradually as in *graciosus*, and not sharply or at right angles as in *occidentalis* and *magister*. It differs from recent skeletons of *S. occidentalis* and *S. magister* by the presence of a large mental foramen in the center of the dentary. It differs from the Pliocene *S. robustus* described by Twente (1952) in lacking the deep excavation on the posterior lateral surface of the dentary.

Stock (1918) gave a summary of the Pleistocene mammalian fauna of the Hawver Cave, which included the extinct *Smilodon*(?), *Nothrotherium*, *Mylodon* and *Mammut*. He suggested that the mammalian assemblage living in the region of the cave at that time included a greater number of plains types than did the Potter Creek Cave fauna. All the extinct genera of mammals, with the exception of *Euceratherium*, are known to occur also at Rancho La Brea. According to Stock, the rodents seem to reflect mainly the Upper Sonoran Life Zone.

The avifauna of Hawver Cave (Miller and De May, 1942) is notable for the preponderance of vultures and hawks, but it also includes such species as the California quail, red-shafted flicker, Steller's jay and possibly the Brewer blackbird, all tending to indicate somewhat of an open Upper Sonoran or Dry Transition Life Zone.

That the herpetofauna of this cave was of either an Upper Sonoran or a Transition Life Zone is suggested by the fact that the rattlesnake and the two lizards are found predominantly in those zones today (Fitch, 1936; Smith, 1946).

McKittrick Asphalt

The McKittrick asphalt traps are located in Kern County, California, at the southern end of the San Joaquin Valley, approximately 400 miles south of Potter Creek and Hawver caves and approximately 100 miles north of Rancho La Brea.

Miller (1942) recorded the desert tortoise, *Gopherus agassizi*, from the McKittrick Asphalt.

One box in the Los Angeles County Museum contains 24 pieces of shell (mostly marginals) that appear to belong to the Pacific pondturtle, *Clemmys marmorata*, and until further material is available of dermal bones of the shell, these are here referred to this species.

A small lizard vertebra (U. C. Mus. Paleo. No. 35128) from the McKittrick Asphalt is indistinguishable from *Eumeces* and, on the basis of size, is referred to *E. gilberti*. It has been compared with *Elgaria* (from which it differs in not having two processes, or parapophyses, at the anterior base of the centrum), with *Sceloporus* (from which it differs by the absence of the deep notch medial to the prezygapophyses), with *Gambelia* (from which it differs primarily in size and shape of the centrum and in the absence of the wide anterior spread of the centrum), and with other genera of southwestern lizards (from which it differs in general shape).

In addition to the above, one vertebra (U. C. Mus. Paleo. No. 35112) is referred to *Sceloporus occidentalis* on the basis of the deep grooves medial to the prezygapophyses, and of the size and shape of the centrum ventrally. It is a large specimen—large enough for *S. magister*—but it is shorter and stubbier than the elongate vertebrae of that species.

The fossil dentary and maxillary bones with bifid teeth can be readily referred to *Cnemidophorus*. These have been compared with skeletons of *C. hyperythrus beldingi*, *C. sexlineatus* and *C. tigris* as well as with figures and descriptions in Burt (1931), Du Bois (1943), and Taylor (1941). On the basis of size, number of teeth, shape, mental foramen counts, and the presence of a depression on the outer surface of the maxilla, the bones from McKittrick are referred to *C. tigris*.

Two maxillae of a fossil iguanid with trifid posterior teeth, when compared with all the genera of lizards of southwestern United States appear indistinguishable from *Gambelia wislizeni*. They can be differentiated from *Crotaphytus collaris* by the somewhat trapezoidal shape of the dorsal portion (triangular in *Crotaphytus*). The foramen and teeth resemble those of *Gambelia* more than *Crotaphytus*. The measurements made on the fossils are more

like those of *Gambelia w. wislizeni* from Southern California than the present *G. w. silus* from San Joaquin Valley (Fig. 2).

On the basis of measurements, all of the *Crotalus* vertebrae from McKittrick can be referred to *C. viridis* (Table I). Most of the vertebrae are smaller than normal for the species, which might indicate that the McKittrick area was cooler at the time of deposition

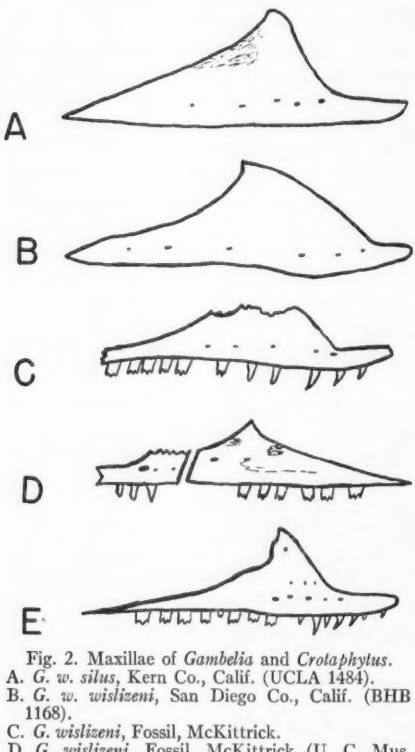

Fig. 2. Maxillae of *Gambelia* and *Crotaphytus*.
A. *G. w. silus*, Kern Co., Calif. (UCLA 1484).
B. *G. w. wislizeni*, San Diego Co., Calif. (BHB 1168).
C. *G. wislizeni*, Fossil, McKittrick.
D. *G. wislizeni*, Fossil, McKittrick (U. C. Mus. Paleo. 35127).
E. *C. c. baileyi*, San Diego Co., Calif. (BHB 1169).

than were the La Brea, Potter Creek, and Hawver localities. The centrum cup in *C. viridis* is generally round, at least more so than in the *atrox* group. The zygosphene is smaller in *viridis* than that in either the *atrox* group or in *C. mitchelli*. A detailed discussion of these relationships is in progress.

The majority of the colubrid vertebrae from McKittrick can be referred to *Pituophis*

TABLE II

MEASUREMENTS (IN MM.) OF MAXILLAE OF *Gambelia* AND *Crotaphytus*

Species	Specimen No.	Length	Height	Length of anterior process	Length maxilla/length anterior process
G. w. silus	UCLA 1484	14.0	5.2	3.3	4.24
G. w. silus	UCLA 1485	14.6	6.5	4.1	3.56
G. w. wislizeni	BHB 1190	15.9	4.9	2.6	6.12
G. w. wislizeni	BHB 1168	14.2	4.3	2.1	6.76
G. w. wislizeni	BHB 887	13.2	5.7	2.6	5.07
Fossil McKittrick	....	8+	2+	2.0	....
Fossil McKittrick	UC 35127	11.5	...	2.1	5.47
C. c. baileyi	BHB 1169	10.9	3.6	2.0	5.45

TABLE III

SUMMARY OF MEASUREMENTS (IN TENTHS OF MM.) OF THORACIC VERTEBRAE OF *Pituophis catenifer*, FOSSIL AND RECENT

Measurements of recent forms are taken from skeletons of *P. c. catenifer*, *P. c. deserticola* and *P. c. annectens*

Measurement	Locality Number of specimens; range (in parentheses) and average of measurements		
	McKittrick	La Brea	Recent
VERTEBRAE	30	12	7
Height	23 (40-60) 50	12 (52-75) 63	6 (59-117) 79
Width	22 (28-35) 32		4 (39-61) 48
Length of centrum	30 (30-57) 45	12 (46-73) 56	7 (44-79) 58
NEURAL SPINE			
Height	19 (9-20) 15	11 (11-24) 18	6 (20-48) 29
Width	19 (23-46) 35	10 (38-61) 42	6 (30-62) 44
PREZYGAPOPHYSES			
Width across	21 (53-82) 67	12 (79-108) 91	7 (80-158)111
Width of process	24 (8-15) 11	11 (6-12) 9	5 (12-23) 18
POSTZYGAPOPHYSES			
Width across	25 (39-64) 53	12 (53-75) 66	6 (60-123) 83
Width of process	24 (8-17) 12	12 (12-21) 16	7 (10-29) 18
CENTRUM			
Height	28 (12-2) 15		7 (17-34) 24
Width	28 (14-22) 17		7 (21-33) 25
ZYGOSPHENE			
Width	25 (20-33) 28	12 (27-44) 34	7 (32-5) 40
Height from centrum	26 (16-27) 21	12 (19-28) 24	7 (22-40) 30
Width of process	24 (8-14) 11	12 (10-23) 15	7 (10-23) 16

catenifer on the basis of size, shape, and the absence of a sub-centrum keel or hypapophyses as present in *Lampropeltis* and *Thamnophis*. *Pituophis* also has small hook-like anterior corners of the zygosphene. The measurements of the fossil specimens (Table III) fall within the variation found in skeletons of *P. catenifer* and its subspecies; they are somewhat smaller than normal for the species and are also smaller than those from Rancho La Brea. This size trend was also noted in the McKittrick populations of *Crotalus viridis* and may indicate a cool climate at the time of deposition of the asphalt.

One fragment of the anterior end of a dentary (U. C. Mus. Paleo. No. 35116) agrees in size and shape with *Pituophis catenifer*.

Two posterior thoracic vertebrae (U. C. Mus. Paleo. No. 35110) are tentatively referred to *Lampropeltis getulus* due to the presence of a large sub-centrum keel.

Miller and De May (1942) discussed the fossil birds from McKittrick and mentioned that "The trap at McKittrick was located in a more nearly flat country and there is a strong indication of considerable accumulation of shallow water, muddy flats and grassy places." Miller (1935) compared two faunas from McKittrick, one being primarly aquatic and the other primarly non aquatic. The drier habitat included such forms as horned larks, meadow larks, house finches, Bell's sparrow, California jay, cactus wren, sage thrasher and loggerhead shrikes.

The McKittrick asphalt includes such typical Pleistocene forms as *Arctotherium*, *Mylodon*, *Canis dirus*, *Felis atrox*, *F. daggetti*, *Bison* and *Mastodon* (Hay, 1927).

A preliminary study of the flora of McKittrick has been given by Mason (1944); the flora includes *Pinus monophyla*, *Juniperus californica*, *Arctostaphylos glauca*, *A. pungens*, *Echinocystis fabacea* and *Atriplex lentiformis*. All but the last-named type probably occupied the higher slopes and were carried down to the pits by streams. *Atriplex* typically grows near ponds and marshes, but its presence does not necessarily indicate water.

The reptilian fauna would suggest an area and a climate similar to, or a little cooler than, that found in the area today. *Clemmys* is found in areas of permanent water, but the Desert Tortoise is primarly an open-desert dweller. *Eumeces* is more likely to be found in moist situations. The rest of the fauna would suggest a more arid condition, and the area was probably at the lower edge of a Pinyon–Juniper association with the temperature probably a little cooler than that of today and perhaps with more rainfall.

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Herpetological Notes

THE FOUR-TOED SALAMANDER, *HEMIDACTYLIUM SCUTATUM*, IN NOVA SCOTIA.—The first published record of *Hemidactylium scutatum* from Nova Scotia appeared in an article by Richmond in 1952 (Ann. Carnegie Mus., 32: 331–32). The specimen was collected by Mr. Gordon MacMillan at Baddeck Bay, Victoria County, Cape Breton Island, on August 14, 1950. There are, however, two additional records both from the mainland of the province. In presenting these it is hoped that any suspicions which possibly were raised by Mr. Richmond's lonely record of an isolated population in the Baddeck region of Cape Breton Island, or of an accidental introduction of that individual specimen, will be dispelled. These new records illustrate the important point that published distribution maps are tentative and show in actuality the range of the collecting rather than that of the species collected.

The first record for the province dates back to 1934 when the Arthur Dean's Nursery in Halifax sent a specimen to the Nova Scotia Museum of Science in Halifax. The salamander was correctly identified, but, because the northern limit of its range was believed to be southern Maine, the occurrence of this specimen was credited to introduction via ship's cargo. However, when in 1951 the nursery records were consulted, it was revealed that this four-toed salamander had actually come from a load of moss gathered for the nursery from just outside the city.

The stimulus for checking this old record was the collection of a 79.4-mm. male four-toed salamander by the writer on April 11, 1951, in Queens County. The site of this latest collection is approximately 80 miles south of the first one at Halifax, and nearly 250 miles south of the Baddeck Bay record.

By evidence of these records, I believe that future herpetological investigations will reveal *Hemidactylium scutatum* to be common in Maine and the Maritime Provinces. Mr. James A. Fowler's collection near Augusta, Maine (1942, Copeia (3): 185–86) extended the known range of this species about 100 miles, as is evident on Bishop's distribution map (1943, Handbook of Salamanders: 307). This Maine specimen and the three widespread records within Nova Scotia certainly are major contributions to our knowledge of the northern range of the four-toed salamander.—Sherman Bleakney, *National Museum of Canada, Ottawa, Ontario, Canada.*

A NORTHERN RECORD OF *HYLA ARENICOLOR* IN WESTERN COLORADO.—Several canyon treefrogs (*Hyla arenicolor* Cope) were seen in a rocky pool of John Brown Creek, 2 miles south and 1 mile west of Gateway (38° 39′ N, 108° 59½′ W), Mesa County, Colorado, on June 21, 1949. The pool was at an elevation of 5300 feet where the creek flows rapidly through a narrow canyon on the eastern flank of the La Sal Mountains. Lanceleaf cottonwoods (*Populus acuminata*) grew along the creek, and the steep slopes were wooded with piñons (*Pinus edulis*) and junipers (*Juniperus utahensis*). I captured two of the treefrogs, which are now preserved in the Museum of Natural History, University of Kansas (Nos. 32515 and 32516).

The nearest locality previously reported, to my knowledge, is Escalante, Garfield County, Utah (Tanner, 1931, Utah Acad. Sci., 8: 187). The specimens from John Brown Creek extend the known range approximately 150 miles northeast of Escalante. Equivalent habitats and zonal situations are to be found still farther north and east on the tributaries of the Green and Colorado rivers, where *Hyla arenicolor* may be expected to occur. The only previous specimen from Colorado seems to be that from the Mesa de Maya, Las Animas County, in the southeastern part of the state, reported by Ellis and Henderson (1913, Univ. Colorado Studies, 10 (2): 59).

Numerous chiggers of the genus *Hannemania* (family Trombiculidae) were imbedded in the skin of the belly and of the underside of the thighs on each of the two specimens collected. The chiggers have been deposited in the collection of the University of Kansas.—Robert B. Finley, Jr., *Museum of Natural History, University of Kansas, Lawrence, Kansas.*

ADDITIONAL RECORDS OF THE TOAD *BUFO COGNATUS* IN ALBERTA.—In the literature dealing with Alberta amphibians there is only one reference to *Bufo cognatus* and that is Logier's record of a specimen collected at Medicine Hat in 1928 (1931, Can. Field Nat., 45: 90). During the summers of 1950 and 1951, the writer and Mr. R. Lister obtained this species from several widely separated localities in southern Alberta. A single juvenile was taken in the Lost River valley south of Onefour in 1950; while adult specimens were collected in the vicinities of Empress and Medicine Hat, and juveniles from Suffield, Taber and Vauxhall in 1951. These records indicate that the Great Plains toad is an inhabitant of the prairie region of Alberta north almost to 51° of latitude.

Mr. E. B. S. Logier of the Royal Ontario Museum of Zoology identified the Lost River specimen and has confirmed the identification of those from Suf-

field, Taber and Vauxhall.—J. E. Moore, *Department of Zoology, University of Alberta, Edmonton, Alberta.*

THE COLLECTION OF A MAPTURTLE IN EASTERN MASSACHUSETTS.—On June 11, 1950, a mapturtle (*Graptemys geographica* Le Sueur) was collected in Lake Waban at Wellesley, Massachusetts. Since the location of collection in eastern Massachusetts is somewhat east of the normal range of the species (into New York and Pennsylvania), it is felt worthwhile to record the incident here. The specimen was an old animal, and two holes had been bored in the posterior marginals of the carapace. The right eye was blinded. It is possible that the animal had been released in Lake Waban by another captor.

On June 20, 1950, the turtle deposited a single egg in a large indoor aquarium in which it was being kept. It is not known whether or not the egg was fertile.—James M. Moulton, *Department of Biology, Bowdoin College, Brunswick, Maine.*

DIGITAL TREPIDATION IN THE SUBSPECIES OF THE TOAD *BUFO WOODHOUSEI.*—A group of twenty specimens of Fowler's toad (*Bufo woodhousei fowleri*), collected in Porter County, Indiana, were observed to exhibit a peculiar toe-vibrating behavior. Firschein (1951, Copeia (1): 73–74) described a similar behavior in the Mexican toad *Bufo nayaritensis*. The fourth toe of the hind foot is jerked spasmodically down and up very rapidly, but occasionally the toe is jerked around in a somewhat circular motion. Sometimes the toads vibrate the fourth toe of one foot, or of both feet alternately, or of both feet simultaneously. No other toe but the fourth is involved.

The digital trepidation lasts for no more than 2 or 3 seconds, followed by a pause of about the same duration, then another period of trepidation. This sequence may be repeated several times. During trepidation the hind foot may be held either with the lower surface off the ground, with the exception of the heel, or completely in contact with the ground.

Firschein (*op. cit.*) observed this behavior in amplectant toads, where it seemed to be related to breeding activity. In *Bufo woodhousei woodhousei*, and *Bufo w. fowleri* this behavior had no apparent relationship to breeding. Firschein observed only male toads exhibiting this behavior, while I have observed it in both sexes. Although both subspecies show this behavior, it appears to be more common in *B. w. fowleri*. Observations on these toads were made in July and August, 1952.

Bufo w. fowleri.—Toads of this subspecies were observed to perform this toe-vibrating sequence with no apparent stimulus other than, possibly, my presence. A female that had been facing away from me turned around toward me, and began vibrating the fourth toe of both hind feet simultaneously. This would seem to indicate that my presence provided the stimulus; however, at other times I observed the toe-vibrating sequence when I was positive that the toads were not aware of my presence, at least by sight.

The presence of living food also seems to produce the behavior. A male was observed leaning against the side of the cage, intently watching live mealworms in a jar placed nearby. The fourth toe of its left hind foot was vibrating with such force as to make a very audible tapping as it struck the cage floor. At another time a male vibrated its toe just after eating a mealworm, and a female did likewise four times while watching another toad feed.

A female, removed from the cage and placed in a glass jar, began digital vibration immediately. After a minute or so of confinement, it became very much agitated and made attempts to escape, during which time vibration occurred for a fleeting moment only. Finally it emptied its bladder and began digging motions. This type of reaction to confinement was observed several times.

Heating the toads with a desk lamp was the most effective means of producing the toe-vibrating behavior. Upon placing the heat source over the large cage so that the direct rays of the lamp were focused on only one half of the cage, vibration was observed only among the toads in that half of the cage. One female jumped up at the heat source several times, and upon each landing vibrated the toe. The periods of trepidation lengthened after each leap. Heating a toad at a time in a glass jar prompted a similar reaction; as it became more uncomfortable, it would make violent attempts to escape, including leaps at the lamp, continuing the trepidation meanwhile. Often the bladder was emptied, and a digging action was exhibited.

Bufo w. woodhousei.—Six specimens of this subspecies were available. Digital trepidation was not prompted by my presence, by the presence of food, or by confinement; however, application of heat in the same manner as with *B. w. fowleri* produced similar reactions. After 25 to 30 minutes of heating, the attempts to escape became more violent, and toe vibrations occurred as the toads tried to find a way out by leaping or digging.

Bufo cognatus.—The same experiments were carried out with this species. No digital trepidation was observed under any conditions, although the sequence of other actions upon heating was similar.

I wish to thank Messrs. Karl P. Schmidt, D. Dwight Davis, and A. Stanley Rand for their many helpful suggestions, and Dr. Max C. Shank for his aid in collecting specimens.—Carlos B. Bumzahem, *1929 Bissell St., Chicago 14, Illinois.*

OBSERVATIONS ON THE ECOLOGY OF THE TOAD *BUFO CANORUS*.—The Yosemite toad (*Bufo canorus*) is a little known amphibian of the boreal life zones in the Sierra Nevada Mountains. This paper is based on some ecological observations made on this species in Yosemite National Park, California, during the summers of 1950 and 1952.

The observations were made principally from September 14 to 17, 1952, around the lakes on the crest of Tioga Pass at 9,900 ft. elevation, and around the lakes and streams of the adjacent Gaylor Lakes Basin at 10,100 to 10,800 ft. Distributional notes were taken during August 19–20, 1950, at Elizabeth Lake, 9,500 ft., and at adjacent Johnson Lake, 10,300 ft.

Toads were numerous about the lakes on the crest of Tioga Pass and at a lake located at 10,100 ft. on the northwestern side of the Gaylor Lakes Basin. They were also common along the stream flowing from Upper to Middle Gaylor Lake and along the stream flowing into the lake located at 10,100 ft. The toads became less common upstream, and the source lake of this stream, at 10,700 ft., had only one toad observed in its vicinity. Upper Gaylor Lake, at 10,800 ft., a timberline lake ringed by snow banks, also had only one observed toad. Middle Gaylor Lake, 10,500 ft., had few toads in its vicinity; the apparent scarcity of the toads here may be due to the elevation or to the effect of numerous fishermen.

The above areas are on southern and western exposures. Toads were also present at nearby Elizabeth Lake, but none was observed in the vicinity of Johnson Lake. These lakes are on northern and eastern exposures. Slope exposure seems to affect the elevational distribution of the toads. Conditions become too rigorous, apparently, for the existence of the toads in normal numbers at elevations between 10,200 and 10,700 ft. on warm exposures, and between 9,500 and 10,300 ft. on cold exposures.

The lakes have a glacial origin and are surrounded by a subalpine and alpine-arctic meadow type of vegetation resembling tundra. The forest is composed of lodgepole pine (*Pinus murrayana*) and white-bark pine (*Pinus albicaula*). Adult toads were common on the margins of lakes, streams, and pools wherever the tundra was deeper and more luxuriant than usual or where there were patches of low willows. Although no toads were found on the dry forest floor, some were found in dry but green meadows.

When frightened, the animals either hopped into the water or, by moving backward, entered rodent burrows.

On August 18, 1952, two of three females examined were heavily gravid; the eggs appeared to be nearly ready for deposition. Wiggins (1943, COPEIA (3): 197) reported taking a gravid female, with eggs ready for deposition, on August 11, 1942.

Tadpoles were observed only in a brackish, red-tinted pond on Tioga Pass, in similar ponds bordering the lake located at 10,100 ft., and in this lake. The ponds were seldom more than 12 inches deep. In the lake the tadpoles were present only in the very shallow marginal waters, principally along a shallow delta where the stream entered. Many of the lakes are entirely enclosed by a margin of tundra several inches high, and the water is several inches deep where it abruptly ends at this wall. With the absence of shallow margins and of an easy access to the water, tadpoles were absent; neither were they found in quickly flowing streams.

Young toads were common, but not abundant, in the meadows surrounding the lakes. Like the adults in similar habitats, the juveniles also move backwards into rodent burrows when disturbed.

One of the most interesting observations was concerned with the daily cycle of activity. About the lakes on Tioga Pass, the toads were active only while their immediate areas were in sunlight. At sunset the toads left the surface for subterranean rodent burrows. Air temperatures at this time were 11–14° C. Stebbins (1951, Amphibians of western North America: 246) noted the diurnal activity but made no mention of nocturnal inactivity. The tadpoles demonstrated corresponding behavior by leaving the shallow margins of the ponds for deeper water where they became inactive.

The value of the habits for diurnal activity and nocturnal inactivity at high elevations is apparent. The author made a study of *Bufo boreas halophilus* (1952, COPEIA (4): 274–76) and found that at night the adult was active with body temperatures as low as 2–3°C. That toad does not occupy as cold an environment as does the Yosemite toad even though the former is well adapted to low temperature. The Yosemite toad's diurnal activity enables it to be active in a colder macroenvironment, but warmer microenvironment, than the western toad. The diurnal activity pattern of *Bufo canorus* might well be a factor which allows it to surpass *Bufo boreas halophilus* in elevational distribution. (On September 7–8, 1952, at Dry Lake in the San Bernardino Mountains, the author observed that the newly matured young of *Bufo boreas halophilus* are not completely nocturnal at this season. The young toads were active during the day and mostly but not wholly inactive at night. This behavior is unlike that of the adults.)

Notable was the small amount of movement by the Yosemite toads. Several adult toads were observed to spend complete days in the same patches of vegetation, and their home ranges at times measured about 20 square feet. Restricted movement was noted only along the margins of water.

Away from water the toads seemed to travel long distances.

Several Yosemite toads around the Gaylor Lakes, examined for stomach content, contained spiders and a random assortment of insects, including ladybird beetles, dragonfly nymphs, mosquitoes, and the larvae of lepidopterans.

The relationship between the Yosemite toad and its associate, the yellow-legged frog (*Rana boylei sierrae* Camp), is not passive. Many times it was observed that a pool containing the tadpoles of toads was also inhabited by one or several of the frogs. Analyses of stomachs revealed that some of the frogs were existing largely upon the tadpoles of the toads. One adult male frog contained 3 tadpoles; a young frog contained 1 tadpole, a ladybug, and 2 dragonfly nymphs; an adult, gravid female frog contained 3 living tadpoles and 6 partially digested tadpoles; another gravid female contained 1 tadpole, 1 ladybug, and a dragonfly nymph.

Another enemy of the Yosemite toad is the dragonfly. A nymph was observed to capture and kill a tadpole.

The tadpoles of the Yosemite toad and yellow-legged frog were not randomly mixed in the breeding areas. As a rule the tadpoles of the two species were in separate groups forming locally dense aggregations of each species, but exceptions were noted. After sundown all the tadpoles disperse to deeper water, and more mixing takes place between the species.

Observations were made on the body and environmental temperatures, using Schultheis mercury thermometers especially made for work on small animals.

Adult toads, with cloacal temperatures of 14.2 to 30.6°C., were found active on soil. The average temperature of eight toads, found within a few yards of each other at 1 PM, was 27.5°C. The air temperature at this time was 18°C., and saturated mud under direct insolation registered 28–30.4°C. When found, the toads were among sedges along a lake shore.

An experiment was performed to test the resistence of the toads to high temperature and intense insolation on a sunny slope at 10,000 ft. elevation. A toad was placed on soil with a surface temperature of 55–65°C. For 13 minutes the toad sat motionless and held a cloacal temperature of 24.0°C.; then its temperature rose to 26.2°C. After 16 minutes at this body temperature, the toad was continually vocalizing and trying to escape from the area.

Voluntarily active toads were found to have body temperatures higher than 26.2°C. Several times the author found toads vocalizing and moving rapidly in the meadows. It may be that these animals had become partially dehydrated by environmental circumstances.

The tadpoles were very sensitive to small differences in water temperature. Often times they deserted areas which were 1–2°C. cooler than the preferred water. Mid-day surface temperatures of the lower Gaylor and Tioga Pass lakes were 20–23° C., while the shallow margins ½–2 inches deep were 27–33°C. Every observation in the daytime, revealed the tadpoles to be crowded into the warmest (up to 33°C.) and shallowest water available. After sundown they dispersed into deeper water. Diurnal warmth probably attracts the tadpoles to the shallow marginal areas; and the coolness of deeper water may prevent normal growth.

The author wishes to thank Dr. Raymond B. Cowles for criticizing the manuscript.—PVT. DON P. MULLALLY, *RH 19432460, Med. Det. 6003 A.S.U., Ford Ord, California.*

THE YOUNG OF THE SNAKE *PITUOPHIS MELANOLEUCUS MELANOLEUCUS.*—On June 9, 1951, my wife and I captured three pinesnakes, *Pituophis m. melanoleucus*, while we explored an area in the Pine Barrens near Warren Grove, Ocean County, New Jersey. These three snakes were 40, 58, and 60.5 inches in total length.

On June 28, 1951, the 58-inch snake laid ten eggs, but laying was not observed. Accounts in the literature pertaining to egg laying are few. Reference was made by Lockwood (1875, American Nat., 9: 3; and 1880, ibid., 14: 528). Moore (1893, ibid., 27: 878) gave a description of a clutch of ten eggs collected on August 3, 1892, at Formosa Bay, Cape May County, New Jersey, and information concerning the embryological development as of August 4.

The eggs laid by my snake were placed in a tin can with a plate for a lid, and were kept covered with about one inch of sand and a constantly moist paper towel. The can was left in one place, on a west-exposure window shelf inside the building where it would be warmed periodically by the sun as well as by the heat of the building. Five of the eggs measured (in mm.) as follows: 55 × 42, 54 × 40, 50 × 41, 55 × 42, and 47 × 41; average, 52.2 × 41.2. Conant and Bailey (1936, Occ. Pap. Univ. Michigan Mus. Zool., 328: 6) mentioned five eggs which averaged 56.0 × 31.3 mm. On August 8, because egg development seemed to be delayed, four eggs were opened, three of which were found to be infertile; the other contained a well developed embryo. On August 17, four of the six remaining eggs were distributed, two to M. Max Hensley and two to William C. Dilger.

The two remaining eggs, which I kept, hatched during the night of September 18. The snakes measured 39 cm. and 35 cm. shortly after birth. I found out later that Dilger's eggs had hatched on Septem-

ber 11, around 2:00 PM. In this case, hatching was observed and was photographed by Richard B. Fischer (Pl. I). Thus there was a difference of 8 days between the hatching of the two sets of eggs, the incubation period being 75 days for Dilger's eggs and 84 days for mine. Hensley's eggs were infertile. Perkins (1943, COPEIA (2): 110), referring to six eggs laid on April 28, 1940, said, "These hatched on July 15, 1940, 78 days later. A young specimen measured 509 mm. (about 20 inches) in length." Referring to another observed mating on January 3, 1941, he said, "The female laid six eggs on February 5. These hatched seventy-nine days later, on April 25, 1941."

Upon hatching, the snakes appeared rather dull in color. On September 21, the eyes of both were cloudy. The eyes cleared on September 26; shedding began on October 3 and was completed by October 5. The new skin was boldly colored and patterned. From the beginning the smaller snake appeared to have a deeper orange coloration along the sides than did the larger snake.

The larger snake has 26 black dorsal saddles from behind the head to the beginning of the tail. The first two saddles are split medially, both being contiguous laterally with each other and with the third saddle which is complete across the back. Each saddle is centered with a dark rich brown. The dorsal ground color is a straw yellow. The interspaces show an olivaceous band over the ground color, which goes across the back. There are seven caudal saddles and these more or less encircle the tail. Lateral blotches vary in size and shape and are centered with the same shade of brown as the dorsal saddles. Only a few lateral blotches are contiguous with dorsal saddles. The head is olivaceous on top. Parietal, frontal, and supraocular scales are spotted black. The anterior edge of the supraoculars and of the frontal, the posterior half of the prefontals, and the dorsal tip of the preoculars are black, forming a broad band. Some labials are brown edged. Ventrally the scutes are clear. Approximately the first six dorsal scale rows on either side are a pale orange; posteriorly this color becomes less intense. There are 214 ventrals and 52 subcaudals.

The smaller snake has a deeper orange coloration along approximately the first six scale rows on either side. This coloration fades posteriorly. There are 26 dorsal saddles from behind the head to the beginning of the tail. The first saddle is incomplete medially but is contiguous on the right side with the second saddle. The saddles are black but, unlike the larger snake, are not centered with brown. The ground color dorsally is straw-yellow and in the interspaces over the ground color there are faint olivaceous bands crossing them laterally. Six black caudal saddles encircle the tail. The lateral blotches are solid black and, unlike the other snake, are not centered with brown. Again the pattern is irregular and some lateral blotches are continuous with the dorsal saddles. The head is olivaceous above and the pattern almost identical with the other snake; the broad band near the eyes is present on the same scales. Ventrally the scutes are clear but a few are edged with black where they meet the first scale rows along the side. There are 210 ventrals and 42 subcaudals.

The umbilical scale scar was noted some time after birth. On one snake it occurs on the 26th and 27th ventral scutes anterior to the anal plate. The scar of the other snake is less prominent and occurs between the 22nd and 27th ventral scutes anterior to the anal plate.

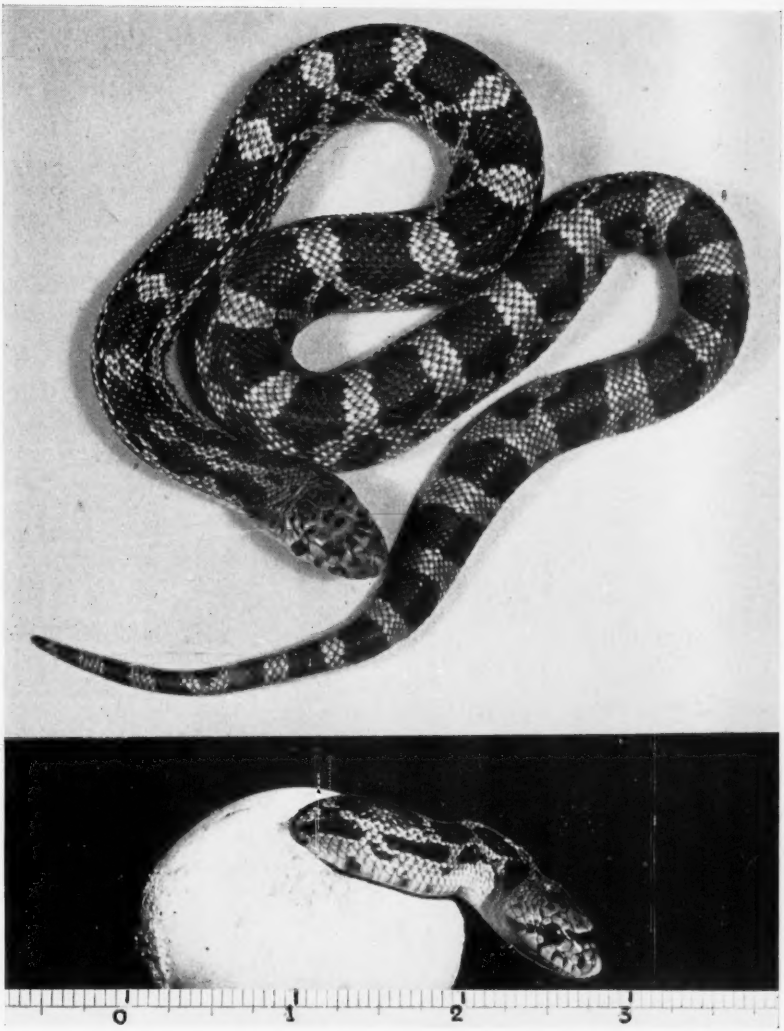
While both young snakes were shedding (with the exuviae still attached), I placed a white mouse (body length about 1 inch) in a gallon jar with them. After a few minutes the larger snake, having shed past its eyes, appeared interested and struck at the mouse but did not hold on. The snake coiled around the mouse in an apparent attempt to constrict it. The snake eventually seized the mouse and ingestion lasted ten minutes; during that period the victim showed respiratory and other body movements. The smaller snake fed for the first time on October 5. The larger snake ate again on the 6th. The smaller snake has always appeared to be hesitant about killing its own food. For a period I force-fed the young snakes egg yolk which was sometimes beaten up in the albumen or with milk. Neither snake would willingly drink this food. Earthworms were offered but always refused. Water was accepted and the snakes would drink from one to five minutes at a time. Early in January, 1952, more white mice were available and the snakes struck at and constricted them as soon as they were placed together.

The adult pinesnake usually hisses when handled; the young snakes also hiss occasionally.

I wish to acknowledge the help of Dr. and Mrs. A. H. Wright who so kindly criticized and helped with this paper. For the photograph of the emerging young I am indebted to Richard B. Fischer, a graduate student at Cornell University.—JOHN G. NEW, *11 Academy Street, Liberty, New York.*

MATING BEHAVIOR OF CAPTIVE LOGGERHEAD TURTLES, *CARETTA CARETTA CARETTA*.—Apparently there is an almost complete lack of information on the mating behavior of loggerhead turtles, and, in fact, of sea turtles generally. Despite certain anomalous features of the events recounted below, it is believed that the present observations include details not previously recorded.

On the morning of May 24, 1952, an adult male Atlantic loggerhead turtle, *Caretta caretta caretta*, was observed attempting to mate with a female of



Young of *Pituophis m. melanoleucas*

Upper: Pinesnake showing color pattern a few days before shedding its skin. Photograph by author.
Lower: Pinesnake emerging from egg. Photograph by Richard B. Fischer. (Scale in millimeters.)

Mating pair of loggerhead turtles in tank at Marine Studios, Marineland, Florida. Photograph by Frank Essapian.

the same species in the circular tank at Marine Studios, Marineland, Florida. This tank is 75 feet in diameter, 12 feet deep, and abundantly supplied with portholes. It contained green, ridley, and loggerhead turtles of both sexes in addition to 12 porpoises and several hundred triggerfish, grunts, snappers, and other bottom fishes.

When first observed, at approximately 8 AM, the male loggerhead was already mounted on the female (which was the larger of the pair), grasping the anterolateral edges of her carapace with the single claw on each foreflipper, and the postero-lateral edges of her carapace with the single claw on each hindflipper (Plate I). The tail of the male turtle was curved downward and forward, with the penis projecting from the cloacal opening.

From time to time during the prolonged copulatory attempts that followed, one or more of the porpoises (*Tursiops truncatus*) would nudge the pair or try, apparently, to pry them apart. This was to be expected of the porpoises which frequently push the turtles about the tank in play. More difficult to interpret was the behavior of two female loggerheads during the earlier part of these observations; they tended to remain near the pair, occasionally bumping against them and biting in an aimless manner at the edges of their shells.

At no time was the male observed to react to these obtrusions. He retained his hold on the female and appeared to be probing with his penis for her cloacal opening. Throughout most of the following events the pair, propelled by the female, moved slowly about, at or near the bottom of the tank.

Approximately one and a half hours after observations had begun, a quantity of black liquid was emitted from the penis which, during this period, had been extended to varying lengths up to an estimated 10 inches. A few minutes later a number of triggerfish (*Balistes carolinensis*) attacked the end of the penis, tearing it and nipping off small bits. Despite the damage caused by the fish, the male persisted in his attempts to copulate. Fourteen minutes after these attacks, the penis, now extended to about 12 inches and directed posteriorly, began to emit large quantities of bright red blood. Although previously bitten, it was not being molested when the blood appeared. The bleeding diminished in approximately one minute, but continued at a reduced rate for a total of 6 minutes; at the end of this time the penis was retracted to a length of 5 or 6 inches. Profuse bleeding occurred again in 5 minutes. The cloud of blood was approximately 18 inches in diameter and, carried by the current in the tank, extended out 6 feet from the turtles before becoming noticeably dispersed in the water. This hemorrhage also lasted for a minute before diminishing to a lesser flow.

During the next 2 hours profuse hemorrhaging occurred four times, each time lasting from 10 seconds to a minute before diminishing rather suddenly. It occurred both while the male was clasping the female and when he was separated from her. The onset as well as the cessation of bleeding appeared to be controlled by the turtle, although mutilation of the end of the penis continued from time to time. The fishes were clearly attracted by the blood and their most severe attacks followed rather than preceded the periods of profuse bleeding. After the third major hemorrhage the penis appeared somewhat shrunken, though it was still capable of being extended to a length of at least 12 inches.

During the course of these observations the male turtle was observed to attempt penetration at least seven times by quick thrusts of the penis. All of the thrusts occurred after the second major hemorrhage, and some occurred when the male had succeeded in remounting the female after releasing her to rise to the surface for air. The thrusts which were most clearly observed began with the penis almost wholly withdrawn into the cloaca; during the thrust the tail extended straight forward at a slight downward angle and was not curved downward and forward as previously described. However during one hard thrust, observed shortly after 10 o'clock, the penis apparently penetrated the female, since the tail of the male was flattened out along the female's plastron in a way not observed at any other time, and retained this position for several minutes. On at least one other occasion a thrust was made with the penis fully extended, but bent at right angles to one side.

Three hours and twenty minutes after observations began, the male released himself, or was dislodged, from the female and surfaced for air. He then returned to the same female and, after some difficulty (the female obviously attempted to avoid him), succeeded in mounting again. In the course of the next hour the pair surfaced together on several occasions; and twice the male released the female to surface, each time returning to the floor of the tank and mounting again. A third surfacing by the male was followed by unsuccessful, though still persistent, attempts to resume the former relationship.

Thereafter the male surfaced repeatedly at one to three minute intervals, with no further attempts to locate and mount the female. Observations were terminated at 12:40 PM. Throughout the foregoing the male had devoted his attentions to the same female, seeking her out after each separation and to all appearances ignoring the other female loggerheads in the tank.

The behavior of the female ranged from passive acceptance to active dislodging or evading movements. On several occasions, using her hindflippers, she seemed to be trying to loosen the grip of the male's hindflippers on her carapace.

With one possible exception at the beginning of observation, the male was not observed to bite at the nape of the female, although all of the female turtles in the tank customarily bear the marks of cervical nipping, presumably acquired in the course of heterosexual activity.

On the day following these observations it was noted that the male loggerhead was apparently unable to retract his penis completely into the cloaca due to a knot-like terminal swelling of the mutilated organ. Furthermore, although no hemorrhaging was seen, the triggerfish persisted in their attacks on the exposed end of the penis. The turtle was therefore transferred to a separate tank that was free of fish, but not until about 3 weeks later was the tip of the penis finally withdrawn into the cloacal cavity.

For certain details in the above account I am indebted to Barbara Lawrence, Museum of Comparative Zoology, Harvard College, who also witnessed these proceedings.—F. G. Wood, Jr., *Marineland Research Laboratory, Marineland, Florida.*

DIURNAL RETREATS OF THE SPADEFOOT TOAD *SCAPHIOPUS HAMMONDI.*—During the breeding season, in April and May, western spadefoot toads (*Scaphiopus hammondi*) occur in great numbers in the seepage pools between the river and highway at Vantage Ferry, Washington. In the evening and at night their loud persistent calls reverberate from the basaltic cliffs along the Columbia River. Although at night they occur in great numbers in these ponds, during the daytime they are completely absent. However, if one examines the sandy borders of the ponds very early in the morning, one may see tracks leading back a short distance and terminating in small pretzel-shaped ridges. These ridges are formed by the wiggling movements of the toad as it digs its way rearward down into the sand. The early morning winds completely obliterate these ridges and thus the burrows are hidden from sight during the daytime.

Although many of the toads retreat into the sand in this fashion, large numbers hide under rocks. These rocks, which are debris from the adjacent talus slopes, are usually flat and about a foot square, and are scattered from 2 to 20 feet from the water's edge. During one collecting trip in the late afternoon and early the next morning, more than 20 adult toads were taken from under such rocks, whereas not a single toad could be found in the ponds. Usually only one toad was found under a given rock; but sometimes as many as four were taken, which were either all young of the preceding year, or one adult and the others immature.

In order to get under the rock, the spadefoot toad burrows horizontally through the sand, forming a pocket. The animal then closes the opening to this pocket by pushing sand into it. This action conserves moisture and hides the entrance.

Associated with the spadefoot in burrows under the same rock were the Pacific treefrog (*Hyla regilla*) and several species of ground beetles and crickets.—Arthur Svihla, *Department of Zoology, University of Washington, Seattle 5, Washington.*

SELECTED RECORDS OF LIZARDS FROM SONORA.—Among the collections made in the summer of 1950 by John P. Figg-Hoblyn, John Lamont, and Jay M. Savage in the Mexican State of Sonora, and deposited in the Natural History Museum of Stanford University (SU), are several lizards that represent notable range extensions.

A skink (SU 14330), collected 11 miles west of Guasabas, was identified as *Eumeces obsoletus* (Baird and Girard) because the lateral scales are in rows oblique to the dorsal rows and because it possesses the characteristic light areas of this species on the scales on top of the head. It is a young specimen, 54 mm. in standard length, and its color is a uniform olive brown above. In all characters it is typical of the species except that the postmental is undivided, a condition noted in only 3 examples of 260 specimens examined by E. H. Taylor for his revision of the genus (Bull. Univ. of Kansas, 36 (14): 314). Mr. Savage informs me that this skink was perched on a small rock in the center of a marshy area which may have been produced by the recent summer rains. This form is an addition to the fauna of Sonora; it represents a 150-mile westward extension of its known range from the nearest recorded Mexican locality (the city of Chihuahua) and is a southerly range extension of 100 miles from Arizona records.

Three specimens (SU 14327–9) of *Phrynosoma platyrhinos goodei* were obtained 2 miles west of Rancho Maria del Carmen (San Francisco), which is 35 miles west of Caborca and 165 miles north of Puerto Libertad, the southernmost locality for the species. In these three examples, the occipital horns are quite short and weak, and there is an abrupt transition between the second and third temporal spines, the last three being enlarged and curved laterally. The last three chin shields are strikingly enlarged. All of these characters are typical of the subspecies. Two of the specimens have immaculate ventral surfaces, but one has a sprinkling of dark dots which is reminiscent of the more northern races of *P. platyrhinos.*

Also in the Stanford collection are two examples of *Phrynosoma platyrhinos* from Punta Peñasco which have short occipital spines, but there is not such an abrupt enlargement of the last three temporal spines as in typical *goodei*, nor are the last three chin shields greatly enlarged. These in-

dividuals show intergrading tendencies between the two subspecies *P. p. calidiarum* and *P. p. goodei*. SU 11779 was collected by Jay M. Savage on the east side of Cholla Bay in March, 1948. SU 9481 was collected by Betty Hammerly in March, 1941. Although the latter example was reported on by Burt and Myers (Stanford Univ. Publ. Biol. Sci., 8 (2): 32) as having two rows of peripheral fringe scales, only one is present. The last row of ventrals is sharply differentiated from the granular dorsolateral area and was presumably mistaken for a second row.

Thus, the three specimens of *Phrynosoma platyrhinos goodei* from Rancho Maria del Carmen represent the most northern examples of this race, and the two from near the head of the Gulf of California in the region of Punta Peñasco are intergrades. Examination of Arizona specimens shows them to be typical of *P. p. calidiarum*. *Phrynosoma p. goodei* is restricted to the coastal dunes of the Sonoran Desert and should be removed from the faunal list of Arizona.—FRANK S. CLIFF, *Natural History Museum, Stanford University, Stanford, California.*

ON THE JUMPING ABILITY OF FROGS.—In a recent paper (1952, COPEIA (1): 15–20), Rand reported on the jumping ability of six species of salientians, viz., *Bufo woodhousei fowleri, Acris crepitans, Hyla crucifer, Rana clamitans, R. pipiens* and *R. catesbeiana*. In comparing species with species, he found the jumping ability to be correlated with the relative length of the hind legs (leg length/body length). For example, the leopardfrog had the greatest relative leg length and also the greatest average length of jump, 937 mm.

In a similar study of the jumping ability within a group of 101 specimens of *Rana pipiens* Schreber (61 from the vicinity of Oshkosh, Wisconsin, and 40 from around Schriever, Louisiana), the present writers found that the ratios of tibiofibula/leg, femur/tibia, and femur/leg showed a statistically significant degree of difference between northern and southern forms, but that the difference between the two groups with regard to relative length of hind leg (body length/leg length, in this case) did not approach significance. The jumping ability of the two groups was compared in much the same manner in which Rand made his comparisons, and the results seem to substantiate the findings he obtained by comparing different species. Just as the body length/leg length ratio did not vary significantly between the two groups, neither did the jumping ability of northern frogs as compared with southern frogs.

The mean length of jump of the 101 leopardfrogs was found by the present writers to be 241.2 mm. which is considerably less than the average length of jump (937 mm.) reported by Rand for the same species. This difference undoubtedly resulted from the fact that Rand allowed the frogs to jump in the grass, while the present writers used a smooth floor for their observations.

In testing the correlation between the various body ratios and the mean length of jump of the entire group of 101 frogs regardless of geographic origin, the formula $r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 + \Sigma y^2}}$ was used; where r = coefficient of correlation, x = the deviation of the length of an individual jump from the mean, and y = the deviation of an index of the relative proportion of some body part from the mean of such indices. The observed values of r were: tibiofibula/leg, 0.102; femur/tibia, 0.103; femur/leg, 0.013; body/femur, 0.150; body/tibiofibula, 0.100; and body/leg, 0.119.

None of the indices correlated with length of jump gave an "r" value which attained either of the usually accepted levels of significance; at least 0.195 is necessary at the 5 per cent level and 0.254 at the 1 per cent level (Snedecor, 1948, Table 7.3). On the basis of the evidence afforded, it cannot be said that changes in the relative proportions of the skeletal parts of the frog hind leg appreciably influence jumping ability.—P. S. STOKELY AND J. F. BERBERIAN, *Department of Biology, University of Notre Dame, Notre Dame, Indiana.*

NOTES ON THE SNAKE *TROPIDODIPSAS GUERREROENSIS*.—In June, 1938, Dr. E. H. Taylor found a specimen of an adult female snake at Buena Vista, Guerrero, which he later used as the basis for the description of *T. guerreroensis*. In 1943, Smith (Jour. Washington Acad. Sci., 33 (12): 372–73) referred a male from Mixtequilla, Oaxaca, to this species. He listed differences between his specimen and the type of *guerreroensis* and pointed out that *T. guerreroensis* of the Pacific slope of southern México and *T. fasciata* in Yucatán are closely related. In 1945, Smith and Taylor (Bull. U. S. Nat. Mus., 187: 151) assigned to *guerreroensis* specimens from Santa Efigénia and Cacoprieto, Oaxaca, which had previously been recognized at *T. fasciata*. These few specimens seemingly mark the extent of our knowledge concerning this species.

It was our good fortune to accumulate a series of seven specimens of *T. guerreroensis* in June and July, 1952, from localities within a radius of 3 miles of Acahuizotla, Guerrero, a town about 15 miles north of Buena Vista, the type locality. All of these specimens were brought to us by local farmers who found them when they were plowing their fields. Although they are all young individuals (total length 187 to 315 mm.), they provide for the first time data on individual variation. The seven

specimens are numbered 7477–7483 in the Texas Cooperative Wildlife Research collection.

TABLE I

MEASUREMENTS (IN MM.) AND SCALE COUNTS OF *Tropidodipsas guerreroensis* FROM ACAHUIZOTLA, GUERRERO

Specimen number	Sex	Ventrals	Subcaudals	Supralabials	Infralabials	Preoculars	Postoculars
Type, after Taylor	♀	198	65	6–6	6–6	2–2	2–2
7477	♂	189	71	6–6	7–7	2–2	1–2
7483	♂	197	72	6–6	7–7	2–2	1–2
7478	♀	189	65	7–7	7–7	2–2	2–2
7479	♀	196	70	6–7	7–7	2–2	2–2
7480	♀	201	78	7–7	7–8	3–3	2–2
7481	♀	197	65	7–7	7–7	2–2	2–2
7482	♀	198	73	7–8	7–7	2–2	2–2

Specimen number	Temporals	Total length	Tail length	Ratio tail to total length	Length anterior chin shields	Length post. chin shields	Diameter of eye
Type (after Taylor	1–1–2	508	103	20.3	3.6	2.5	2.3
7477	1–2–3	315	65	20.6	3.0	2.0	2.1
7483	1–2–3	247	51	20.6	2.8	1.8	1.9
7478	1–2–3	186	35	18.8	2.4	1.5	1.8
7479	1–2–3 / 1–1–3	205	42	20.4	2.6	2.1	1.6
7480	1–2–3	187	40	21.3	2.3	1.5	1.9
7481	1–2–3	233	45	19.3	2.7	1.7	1.8
7482	1–2–3	200	41	20.5	2.4	1.8	1.8

These specimens differ from the type in several respects, chiefly in the number of supralabials, infralabials, and temporals (Table I). No. 7477 has the loreal in contact with the eye between the two preoculars on one side, while the other side is normal; also the first temporal is in contact with the eye on one side, and the lower postocular is absent (or fused with the temporal). No. 7480 has no loreals, and the prefrontals are enlarged laterally and in contact with the supralabials. No. 7479 has the same variation as No. 7480 on one side only; the other is normal. No. 7479 does not have a pair of small scales between the first ventral and the posterior chin shields. No. 7483 has the first temporal in contact with the eye on both sides, wedged between the two postoculars on one side, and replacing the lower postocular on the other; also, it has a small azygous scale between the second pair of chin shields and the pair of small scales anterior to the first ventral. For the 7 specimens, the number of scales between the first ventral and the last infralabial varies as follows: 1 scale, 1; 2 scales, 4; 3 scales, 2.

Considerable variation exists in the color pattern. On the body the number of complete white bands varies from 4 to 13, the number of broken or incomplete bands from 8 to 23; on the tail the number of complete white bands varies from 0 to 2, the number of incomplete bands from 8 to 14. The greatest number of complete plus incomplete bands on the body is 27; the least, 17. Many of the white bands bifurcate laterally and enclose a wedge-shaped black area. In six of the seven specimens the white nuchal collar is complete; in one (No. 7477) it is interrupted at the midline, as in the type. None of the specimens is spotted posteriorly like the type. In only one (No. 7478) do the dark bands reach the midventer, as in the specimen from Oaxaca described by Smith (*supra. cit.*); in this individual the three anterior black bands are complete. In three specimens (Nos. 7480, 7482, 7483) the venter is immaculate; in the others it is spotted or stipled with blackish.—W. B. DAVIS, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas.*

Ichthyological Notes

OBSERVATIONS ON FISH TURNING FLIPS OVER A LINE.—Gudger (1944, Amer. Nat., 78: 451–63) summarized the literature on fishes which leap over sticks, twigs and other floating objects. He listed *Clupea harengus* Linnaeus (the Atlantic herring), three needlefishes (family Belonidae), two halfbeaks (family Hemiramphidae), and three silversides (family Atherinidae) as given to this habit. The observations were made by various workers at Long Island, Bermuda, Dry Tortugas, and Haiti. Hubbs (1948, COPEIA (4): 298) added a Pacific atherinid and an unknown shark to this list. Examination of these accounts shows that fishes in many instances leap clear of floating objects without touching them. C. F. Holder published a photograph of a needlefish clearing a turtle at the surface, which is reproduced in Gudger's paper. Longley (1941, Longley and Hildebrand, Carnegie Inst.

Wash. Publ. 535: 29) noted that the needlefish, *Strongylura raphidoma* (Ranzani), sometimes leaps over a floating fish of its own species. These actions have impressed various observers as being play. Holder (1903, Sci. Amer., 88: 151–52, and earlier) first advanced this idea, and Beebe (1932, Nonsuch: Land of Water, Harcourt, Brace and Co.) said the act appeared to be one of "sheer exuberance."

Breder (1929, Carnegie Inst. Year Book, 28: 279–82) observed that needlefishes very often touched the floating debris as they went over, and although the object was often only a straw or piece of paper, he thought the action "is that of scratching to remove ectoparasites." He stated that some ectoparasites dropped off from the fish on capture, indicating the ease with which they could be scraped off.

Breder (1932, Carnegie Inst. Washington Publ. 435: 15–16) observed a third type of behavior in which the needlefish lays the tip of the bill upon the object and then clears it by a "violent tail action" in such a manner that part of the body usually scrapes the object. Longley also noted that a needlefish would put its bill over a piece of paper and quickly glide across. Swanson (1949, COPEIA (3): 219) saw this behavior with mango leaves. He called it a standing jump or slide and said that the leaves were too soft for parasite scraping and that the "casual, deliberate action" did not suggest exuberance.

Gudger also gave an account of two fishes which flip or somersault over floating objects. The observations were made by Mr. Louis Mowbray of the Bermuda Aquarium, who stated that *Atherina harringtonensis* Goode approaches an object slowly, lays the lower jaw against it, and then with a quick flip of the tail "completes a somersault tail-over-head over the floating object." Mowbray also stated that *Hemiramphus brasiliensis* (Linnaeus) places the tip of the lower jaw under the floating object and at the same time gives a flip, "which almost invariably lands him tail first on the other side."

Thus, four similar types of behavior have been observed in fishes with regard to jumping over floating objects. These are straight jumping with total clearance, jumping without complete clearance, making a standing jump or sliding over with the head or bill upon or just over the object as a preliminary, and turning a flip or somersaulting with the head or bill against the object as a preliminary.

The following observations extend the recorded information on behavior of fishes towards floating objects. On August 29–30, 1952, the writer had occasion to make some log line measurements of currents in Bay Adam, Louisiana, which lies near the west bank of the lower Mississippi River. The salinity ranged from 15.2 to 22.9 *per mille* on August 30. The fauna is typical of the Louisiana oyster region.

The method involved use of a $\frac{3}{16}$ white nylon line which was payed out as a drift pole moved away. Schools of the rough silverside, *Membras vagrans* (Goode and Bean), were always present around the steel barge from which the observations were made and they seemed to be greatly beguiled by the white line in the water. They were almost continuously active and, since current drift was slow, there was ample time for observation of their behavior. About eight hours were spent in current measurements during the two days.

The fish seemed to be interested in the line itself and not solely because it was a surface object. This was shown by the fact that they continued playing with it after it sank. Where the line was a little below the surface, the fish sometimes swam slowly back and forth across it in tight circles or figure eights, turning before their whole length had crossed the line, as if they were reluctant to get far away. In this action, which was sometimes kept up for as long as a few minutes, the fish were above and not touching the line. Occasionally one paused several seconds above the line at right angles to it and about midway across. In no instance was a fish seen to run under the line. The whole movement was slow and casual, showing little exuberance.

These little fish also showed a more vigorous type of activity. My attention was first attracted by distinct little jerks on the line, similar to what fishermen feel when "small fry" nibble and jerk at the bait. Superficial observation would have indicated that the fish ran at the line from a distance of a few inches and struck it a sharp glancing blow as they went over, but that was not the case. The fish were butting the line full force. Whether or not they were trying to butt the line squarely, this sometimes happened, and several times a fish bounced back in the direction from which it came. In most cases, however, the tail was flung up and over, and the fish flipped tail-over-head across the line, usually landing several inches away. Sometimes, on landing, the fish was headed towards the line, whereupon it swam without pause and butted the line again from the other direction. This action went on, both when the line was at the surface and when it was sunk. In the latter case the fish was not flung so far, of course. No fish was seen to go under the line, indicating that they were trying to strike the upper part of the line or possibly were swimming in such a way that they would be propelled over the line rather than under it. This action was quite vigorous and could be called exuberant.

The whole activity gave the impression of being one of play. It could scarcely be parasite-scraping

behavior. It would seem that a fish bent on parasite scraping would occasionally run under a line, would not swim lazily back and forth above a line, and would not butt the line vigorously with its head. In addition, I have handled several hundred of these little fish and have never observed external parasites, although they have been seen on other fishes. In fact, external parasites are relatively uncommon on small fishes, a fact pointed out to me by Dr. A. S. Pearse while he was collecting crustacean parasites of fishes at Port Aransas.

The activity of fishes jumping over or clearing floating debris, as recorded in the papers cited above and in the present account, seems to be a type of behavior which may be called play. A large part of this behavior, especially that involving butting a line, the standing flip observed by Mowbray, or complete clearance of debris without touching, is not connected with parasite scraping. On the other hand, fishes do attempt to scrape foreign objects from their bodies; an example is given below. Some of the behavior of fishes towards floating debris may be concerned with parasite scraping, but the question is not settled, and play seems to be more important. Swanson's account and the present one show that fishes carry out slow, casual movements associated with objects in the water; these movements are not enthusiastic play and are not related to parasite scraping. Swanson's suggestion that this may be explained as "scratching" may be correct in the case observed by him, but in the instance observed by the writer bodily contact was lacking most of the time. Instead, the fish exhibited a mild attraction to, or fascination by, the line, which might be called beguilement, for lack of a better term. It is clear that the behavior of fishes towards small inanimate objects in the water includes a variety of actions and for some of these satisfactory explanations are not yet known.

Gudger noted one observation of fish pushing twigs about with their snouts and one of fish swimming under a twig. An account of a fish swimming under a linear object was told to me by the late J. Nelson Gowanloch. It also adds another fish to the "vaulting" list, although the circumstances are special. Mr. Gowanloch was once engaged in transporting a live jewfish, *Promicrops itaiara* (Lichtenstein), from Bermuda to New York. The tank had a steel rod across it not far under the water. A remora, *Echeneis naucrates* Linnaeus, which was also placed in the tank, attached itself to the larger fish on the dorsal surface back of the head. The jewfish continually tried to scrape the remora off by running under the rod. Each time, the remora leaped deftly over the rod and reattached itself to the jewfish in the same place. Finally, it became necessary to remove the remora from the tank because the persistent jewfish was rubbing itself raw.—G. GUNTER, *Institute of Marine Science, The University of Texas, Port Aransas, Texas.*

A NOTE ON MASS MORTALITY OF THE MYCTOPHID FISH *TARLETONBEANIA CRENULARIS*.—Occasionally there are reports that deepsea or oceanic fishes are washed up on beaches, usually after storms. The shores bordering the Straits of Messina are famous for such occurrences, and Jespersen and Tåning (1926, Rept. Danish Ocean. Exped. 1908–1910, 2(9), A. 12: 4, 7, 22, 38, 40) reported the finding of individuals of several species of deepsea fishes there. Another such event at Blinkenthorpe Beach, Lord Howe Island, is recorded by Whitley (1943, Australian Zool. 10(2): 175). This is a report of a similar occurrence on the Pacific Coast of the United States.

On October 17, 1952, the beach at Stillwater Cove, Pebble Beach, California (Lat. 36° 33′ 59″ N., Long. 121° 56′ 28″ W.) was observed to be littered at the high-water level with the myctophid fish *Tarletonbeania crenularis* (Jordan and Gilbert). The time of observation was 6:45 AM, 25 minutes after sunrise and two hours and 25 minutes before an expected high tide of +4.9 feet. At the time, the sea was calm, with only a weak surge running (less than one-foot surf action), and a slight wind (Beaufort force 1) was blowing from the south-southwest. The sun was shining, the morning was clear, and the cloud cover was estimated to be 60 percent. Records indicate that much the same weather conditions prevailed for the month preceding the find of myctophids.

Along approximately 200 yards of beach there were thousands of fish, all of the same species, all of the same general size range, and all dead. Since I was engaged in taking coastal shore temperatures at the time and still had some 270 miles to drive, not a great deal of time could be spent in observation or collection. However, a random sample of nine individuals of representative sizes was collected, and these were carried in salt water until my return to the laboratory late the same night, when they were preserved in ten percent formalin. All of the fish on the beach were in excellent condition and appeared to have washed in not long before the time of observation. Sea gulls and other shore birds had not yet begun to feed on the dead fish, and the only damage to the specimens was caused by amphipods and isopods which had probably just begun to scavenge.

Three males and six females were collected, ranging in size from 58.4 mm. to 71.0 mm. in standard length. All of these fish are larger than any of the specimens taken in two years of weekly plankton hauls made with a one-meter net by the research vessel TAGE, of the Hopkins Marine Station, in the vicinity of Lat. 36° 42′ N., Long. 122° 02′ W. This

location is approximately ten miles northwest of Stillwater Cove. These hauls have yielded 46 specimens of *Tarletonbeania crenularis* that ranged in length from 12.4 mm. to 52.8 mm. (mean 22.6 mm.).

Stomach analyses of the nine specimens revealed that they were stuffed with euphausiids, probably *Euphausia pacifica*. Apparently the myctophids had been feeding just prior to their deaths, since the euphausiids from their stomachs were only slightly digested.

Examination of the ovaries of the collected specimens indicates that the fish were approaching their spawning time. Four of the six females have eggs measuring up to 0.44 mm. in diameter. These are somewhat ovoid, and measure about 0.36 mm. along the shorter axis. The yolk is well developed, and there are numerous oil globules.

Surface temperature records indicate that the period from September 24 to October 8 was characterized by increasing temperature all along this segment of the coast (Fig. 1). This was evidently due to a mass of warm, oceanic water moving coastwise. Such a phenomenon is characteristic during September and October (Skogsberg, 1936, Trans. Amer. Philos. Soc., n.s., 29: 54–57, Fig. 13). This warm water appears to have had its greatest effect during the week of October 8, when temperatures were generally higher than at any time during the last year. The warming effect of the oceanic water mass was augmented by localized surface warming, due to two weeks of sunny days and mild nights. Further evidence of a warm-water mass is provided by the reports of commercial fishermen, who sighted schools of bluefin tuna (*Thunnus saliens*) and albacore (*Germo alalunga*) in Carmel Bay, off Pt. Pinos, and in Monterey Bay. From October 6 to October 10, schools of these fish were observed to be moving northward. Evidence that *Tarletonbeania crenularis* was present in the area in large numbers during the same period is given by a report from Mr. Cottardo Loero of the General Fish Corporation of Monterey, California. He states that bocaccio (*Sebastodes paucispinus*) and chilipepper (*Sebastodes goodei*), caught on October 10, 1952, in 110 to 120 fathoms of water approximately ten miles west of Pt. Sur (Lat. 36° 18′ N., Long. 121° 53′ W.), were gorged with lantern fishes. He further states that the fisherman reported that the deck of his boat was covered with large numbers of these same fish which had been regurgitated by the rockfishes after they were landed. Dr. R. L. Bolin of the Hopkins Marine Station identified specimens of these as *Tarletonbeania crenularis*.

Surface temperatures of October 17 reveal that a sudden, sharp decline in temperature took place sometime during the preceding week all along this segment of the coast. At Stillwater Cove the drop was 4.6°C (from 16.0°C to 11.4°C), while at the Doud Creek station, which is on the open coast, the drop was 4.9°C (from 15.2°C to 10.3°C). Apparently, intense upwelling occurred between October 8 and October 17, 1952.

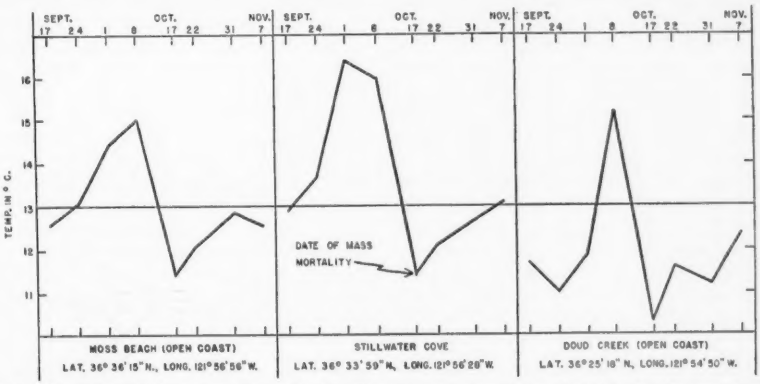


Fig. 1. Thermal conditions preceding and following the mass mortality of *Tarletonbeania crenularis* on October 17, 1952.

Several avenues of speculation as to the causative factors involved in the mass death of a whole school of fish are suggested. (1) The weather must certainly be eliminated at the outset, since no storms or rough seas preceded the finding of the fish along the beach. (2) The sharp change in the surface temperatures, indicating upwelling, suggests another possibility. The upwelled water conceivably could have been of such a composition that one, or several, of the chemical constituents was in a concentration beyond the tolerance of *Tarletonbeania crenularis*, although this alternative seems most improbable. (3) It is possible that the change in temperature

was directly responsible for the mass death. While a variation of between four and five degrees centigrade may appear to be comparatively slight in many regions, it is a relatively great variation in this region, since the central California coast is characterized by great temperature stability. At Pacific Grove the surface temperatures have varied between extremes of 9.3°C and 17.0°C during the last nine years; the average annual variation is only 6.5°C, while the greatest range in any one year was 6.9°C. To open-water fishes accustomed to similar or probably narrower temperature ranges, an abrupt warming or cooling might be catastrophic. (4) Another supposition to be considered is that the lantern fish might have been preyed upon by bluefin tuna or albacore, which are known to feed upon them. In trying to escape their predators, the myctophids might have beached themselves.

Whatever the causative factors of this mortality, they must have exerted their effects swiftly in order to have killed what appeared to be a whole school of these fish, and they must have been specifically lethal for *Tarletonbeania crenularis*, since no other fishes or invertebrates were on the beach. This selective mortality is difficult to explain unless the fishes were driven ashore by predators.

The occurrence was a solitary one. Checks twice daily at Stillwater Cove and the surrounding area during the following week failed to reveal any additional specimens. By the morning following the discovery of these fish, the beach had been swept clean.—ROBERT H. AUGHTRY, *Hopkins Marine Station, Pacific Grove, California.*

NORTHWARD OCCURRENCE OF SOUTHERN FISHES (*FUNDULUS, MUGIL, POMATOMUS*) IN COASTAL WATERS OF NEW HAMPSHIRE.—During the past three years, some fishes new to this region have made their appearance in the Great Bay-Piscataqua River system of New Hampshire. These are as follows:

On April 18, 1950, a male striped killifish, *Fundulus majalis* (Walbaum), 90 mm. in total length, was taken in Great Bay at the mouth of the Lamprey River. During the following spring and summer six additional males and females were taken. During 1951, almost every seine haul brought in one or two, and in 1952, in certain regions of Great Bay, several hundred were frequently taken at one seine haul. In places, they outnumbered the common killifish, *Fundulus heteroclitus* (Linnaeus). Bigelow and Welsh (1925, Bull. U. S. Bur. Fish., 49 (1): 159) stated: "We have never seen this fish in the Gulf of Maine . . . ." Although records of the fishes of the Great Bay region have been kept since 1908 (see Jackson, 1922, Ecology, 3 (1): 48–54), this is the first time that the striped killifish has been reported. Its present numbers seem to indicate that it has become well established.

On October 4, 1951, a striped mullet, *Mugil cephalus* Linnaeus, 80 mm. long, was taken at the mouth of the Oyster River, a tributary of Great Bay. Later, on several occasions, mullet measuring up to 160 mm. in total length were taken by either seine or gillnet. There are few records of mullet from north of Cape Cod. The fact that fourteen fish were taken between October 4 and October 18, 1951 is of interest.

The above records are a further indication of a northern drift of southern species that has been previously noted (Arnold, 1951, COPEIA (1): 87–88; Schuck, 1951, COPEIA (2): 171). Still another indication of this drift was the taking of small bluefish ("snappers"), *Pomatomus saltatrix* (Linnaeus), by smelt fishermen on September 16, 1952 at the mouth of the Piscataqua River, through which Great Bay discharges to the sea. This is the first time bluefish have been taken in this region since 1850, although the species has been reported from the southern portion of the Gulf of Maine from time to time.

Another record for the Piscataqua-Great Bay area was a giant ocean sunfish, *Mola mola* (Linnaeus), taken in the Piscataqua River on June 12, 1951. This fish measured eight feet, two inches in total length and is reported here because of its size rather than its scarcity, although this is the first record of the fish for the Piscataqua-Great Bay river system.—C. F. JACKSON, *Department of Zoology, University of New Hampshire, Durham, New Hampshire.*

HENRY HUDSON'S COMMENT ON SALMON IN THE HUDSON RIVER, SEPTEMBER, 1609.—According to some authorities the natural range of Atlantic salmon (*Salmo salar*) included the Hudson River (Jordan, Evermann, and Clark, 1930, Rept. U. S. Comm. Fish., 1928, (2): 56; Hubbs and Lagler, 1947, Cranbrook Inst. Sci., Bull. 26: 37), but others say or imply that it did not. "Experts doubt the Hudson was ever a salmon stream" (Rept. Comm. Fish. N. Y., 1869: 25). "Salmon was once abundant in the rivers north of the Hudson" (Walford, ed., Fishery Resources of the United States, 1947: 65). Bean (1902, Rept. Comm. Fish. N. Y., 1901: 326) quoted Mitchill's statement (1815) that in the early nineteenth century salmon occurred in the Hudson only as stragglers, and referred to DeKay's report of the capture of such a fish near Troy in August, 1840; but Bean failed to quote the pertinent sentence following the report, namely, "Previous to the setting of so many nets along the whole course of this river, it is probable that salmon were more numer-

ous" (DeKay, 1842, Nat. Hist. N. Y., Zool., 4: 242).

Cheney (1898, Bull. U. S. Fish. Comm., 1897, 17: 247–51) gave special attention to this question, and in his opinion the evidence contained in the early records shows conclusively that the Hudson was not originally a salmon stream. There is at least one questionable argument in this article, and one important early reference that has been overlooked. In the journal kept by Robert Juet on Hudson's third voyage, the salmon is twice reported as having been seen: "many salmons" inside Sandy Hook on September 3, 1609, and "great store of salmon in the river" near the Highlands on September 15. Cheney suggests that, since both Hudson and Juet were Englishmen, they were probably familiar with salmon and that when they saw "schools of large fish of some sort" they called them salmon in the log (248), a curious inference, to say the least, following the premise of familiarity with salmon. Cheney further states that not a single salmon was caught while the ship was in the river, and rests his claim on the argument that, had the Hudson been a salmon stream, the salmon would not have been in the lower part of the river in September but farther up on the spawning grounds. It is clear that Cheney is thinking of adult salmon. Nothing is said, however, in Juet's journal about "large" salmon, and Hudson's own statement, which is overlooked or omitted by Cheney, is that the salmon were *young* and, contrary to Cheney's claim, they were also captured. To my knowledge, the entire journal of Hudson has not been preserved, but portions of it are quoted in John de Laet's *Nieuwe Wereldt* (Amsterdam, 1625) and reprinted in several later publications. The passage in question reads, "Hudson also states that they caught in the river all kinds of freshwater fish with seines, and young salmon and sturgeon" (reprint in Coll. N. Y. Hist. Soc., 2nd Ser., 1, 1841: 300). The oldest records we have of salmon in the Hudson River, Juet's journal and Hudson's comment, do not support Cheney's conclusion. The reason for the scarcity of salmon in the Hudson in the early nineteenth century may well be the one suggested by DeKay, quoted above. —ERHARD ROSTLUND, *Department of Geography, University of California, Berkeley 4, California.*

IDENTIFICATION AND RELATIONSHIPS OF THE ANCHOVY DESCRIBED FROM CALIFORNIA AS *ANCHOVIA SCITULA*.[1]—Species known only from type descriptions are always bothersome, particularly when they were described from regions where the fauna has been exhaustively studied. Of such species in the California marine fauna one of the most troublesome was described by Fowler (1911, Proc. Acad. Nat. Sci. Phila.: 211–12, fig. 2), on the basis of one specimen (A.N.S.P. No. 1576) recorded as having been collected at San Diego by W. N. Lockington. Under the name *Anchoviella scitula*, the species was accepted as valid by Jordan, Evermann, and Clark (1930, Rept. U. S. Comm. Fish., 1928, pt. 2: 49) and by Hildebrand (1943, Bull. Bingham Oceanogr. Coll., 8 (2): 109–12, 118–19, fig. 50). After studying and redescribing the holotype, Hildebrand concluded that the species approaches *Anchoa* and that it seems to be most closely related to *Anchoa exigua*. He added that "the specimen on which this species is based seems to be as unique to the fauna of the Pacific Coast of the United States as *Anchoa duodecum* [*sic*] is to the Atlantic." McHugh and Fitch (1951, Calif. Fish and Game, 37: 494–95), in reopening the problem, have commented on the possibility that the type may be an aberrant example of *Engraulis mordax* Girard. "It seems highly unlikely," they concluded, "that the species is valid."

A reexamination of the evidence convinced me that the type can not be an example of *Engraulis mordax*, for the pelvic and anal fins are much too far forward, the caudal peduncle much too long, the maxillary much too short and too rounded, the pectoral axillary scale much too short, and the gillrakers and scales as well as the anal rays too few. Dr. Robert R. Harry, in kindly determining that the type has 4 short but well developed rakers in the posterior series of the upper limb of the third arch, where *Engraulis mordax* has none, has provided the data that clinch the decision.

It is clear from a study of Hildebrand's key (pp. 109–11) to the species of *Anchoviella* that the type of *scitula* fits into items a, b, cc, e, and f. Under f there are recognized, in addition to *scitula*: (1) *A. perfasciata* (Poey) of the Atlantic, which has the axillary scale much longer, the anal fin much farther back, and the rakers somewhat more numerous; (2) *A. brevirostris* (Günther) of Amazonian fresh waters, a deeper-bodied fish with fewer pectoral rays; and (3) *A. miarcha* (Jordan and Gilbert), known only from young to half-grown specimens, 28 to 45 mm. long, from Mazatlán to Panamá and apparently from the Galápagos Islands. The only differences of importance between *scitula* and *miarcha*, as described by Hildebrand, are the higher number of rakers (15 to 18 + 23 rather than 12 to 14 + 18 to 20), the shorter head (4.4 versus 3.8 to 4.1), and the larger eye (3.4 versus 4.6 to 5.5). The differences in proportion may be explained by age variation, for the specimens of *miarcha* are not much beyond the postlarval stage, which in anchovies is small-eyed, and, in specimens equally large (97 mm. to end of broken caudal fin, 84 mm. to base of caudal), the head would probably have

[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 626.

decreased in relative size to the values shown by the type of *scitula*. Similar age changes in the relative sizes of the eye and the head may be observed in other species: for example, in series of *Anchoa mitchilli mitchilli* (Valenciennes) from New York the head measures 3.6 to 4.0 into the standard length in large young and half-grown, 4.0 to 4.4 times in adults, and the eye enters the head 4.3 to 5.0 times in the smaller specimens, 3.6 to 4.4 times in the larger. It is highly probable that the discrepancy in raker number can also be explained. There is presumably some increase in number with age, as I have noted in several species of anchovies and as McHugh (1951, Bull. Scripps Inst. Oceanogr. Univ. Calif., 6: 148–50, fig. 5) has proved to be maintained throughout life in *Engraulis mordax*. Furthermore, the type of *scitula* may have rakers near the maximum number for the species it represents. Since only 1 and 6 counts are given for the respective nominal species, it is to be expected that in large series of counts, values as high as those of the type of *scitula* will be obtained in adults of *miarcha*.

It is concluded that *Anchovia scitula* Fowler was based on an adult specimen of *Anchoviella miarcha* (Jordan and Gilbert). This interpretation removes the doubt that Hildebrand felt regarding the generic reference of *miarcha* to *Anchoviella* and renders it unlikely that its resemblance to *Anchoa exigua* is an indication of close relationship. Though additional morphological differences would be very welcome, it seems that Hildebrand's distinction of *Anchoviella* and *Anchoa* is justified, particularly in view of the different centers of geographic and ecological distribution.

It seems probable that *Anchoviella miarcha* occurred in southern California during the warm period of the middle 1800's (Hubbs, 1949, Jour. Mar. Res., 7, 1948: 459–82, figs. 1–6) and was still at San Diego when Lockington collected a specimen there about 1880. It is possible, however, that the type of *Anchovia scitula* was taken by Lockington in the Gulf of California, where he is known also to have collected. There is a remote possibility that it represents a form, probably now extinct, that was differentiated subspecifically or specifically from *A. miarcha*.

It seems almost certain that *Anchoviella miarcha* no longer occurs in or near California. No specimens have been secured in the extensive recent collecting along the coasts of southern California and of western Baja California, by the California Department of Fish and Game and by Scripps Institution of Oceanography (McHugh and Fitch, *loc. cit.*), and in the Gulf of California, by Boyd W. Walker and students of the University of California at Los Angeles (I am grateful to Dr. Walker for this information). The range of the species seems to have become contracted to more tropical waters.

The genus *Anchoviella* as a whole, contrasting with *Anchoa*, is primarily South and Central American and is chiefly fluviatile (Hildebrand, *loc. cit.*). The only other species known from north of Central America are *A. parri* Hildebrand, of the Gulf of California, which has more anal rays than *A. miarcha* (23 to 26; the figures misplaced in Hildebrand's tabulation on p. 111); *A. analis* Miller (1945, Jour. Wash. Acad. Sci., 35: 265–67, fig. 1), a very different species from Laguna de Mexcaltitan, Nayarit, México; *A. perfasciata* (Poey), of the West Indies; and the species described by Swain and Meek from Woods Hole, Massachusetts as *Stolephorus eurystole*, and generally identified with *Engraulis argyrophanus* Kuhl and van Hasselt (in Valenciennes, 1848, Hist. Nat. Poiss., 21: 49–50), from the equatorial Atlantic. The last species, of sporadic occurrence along the Atlantic Coast of the United States, seems to parallel *A. miarcha* in some distributional respects. It presumably also has a permanent abode in more tropical waters. Hildebrand (*loc. cit.*: 109–18) failed to separate it conclusively from the species that he described from Venezuela as *A. estauque*. This name should be spelled *estanquae*, because the new rules of nomenclature demand the correction of erroneous spellings derived from misread labels (Schultz, 1949, Proc. U. S. Nat. Mus., 99: 47–48, indicated the correct spelling of the type locality to be Estanques Bay). Whether this Atlantic relative of *A. miarcha* should be known as *A. eurystole* (Swain and Meek) or as *A. argyrophanus* (Kuhl and van Hasselt) can not be ascertained without an examination of the types of *argyrophanus*. This species has occurred as far north as Lynn Harbor, Massachusetts, where I seined a 51-mm. specimen (U.M.M.Z. No. 140642) in August, 1928.—Carl L. Hubbs, *Scripps Institution of Oceanography, University of California, La Jolla, California.*

NOTES ON GULF OF MAINE FISHES IN 1952.—The following observations were made during the Atlantic herring investigation sponsored by the Maine Sardine Packers Association, Maine Department of Sea and Shore Fisheries, Maine Sardine Industry, and the U. S. Fish and Wildlife Service.

Etrumeus sadina (Mitchill); Atlantic round herring.—During August and September, 1952, the Atlantic round herring was a common fish in Maine waters. This species rarely strays north and east of Cape Cod (Bigelow and Welsh, 1925, Bull. U. S. Bur. Fish., 40 (1): 92). It has not been possible yet to obtain data on the exact quantities of round herring caught in Maine; however, I estimate that at least 3,000 bushels (210,000 pounds) were landed.

Some specimens of this species were mixed with Atlantic herring (*Clupea harengus*) and taken to sardine canneries. The greatest quantities were used for lobster bait or fish meal. For a chronological account of the 1952 appearance of this species on the Maine coast, see Scattergood (1952, Maine Coast Fisherman, 7 (2): 8). Most of the fish were caught around the Mount Desert Island–Swans Island area. A sample of 32 fish ranged in length from 138 to 157 mm., with a mean length of 145. 8 mm. The copepod, *Calanus finmarchicus* (Gunnerus), was present in most of the stomachs.

Sarda sarda (Bloch); Atlantic bonito.—During June 1952, a 219-mm. bonito was caught in a mackerel gillnet in Boothbay Harbor, Maine, and on Sept. 27, 1952, a 359-mm. specimen was taken in a herring stop seine at Southport Island, Maine.

Coryphaena hippurus Linnaeus; dolphin.—When a sportsfisherman in Peeble's Cove, Cape Elizabeth, Maine, noticed a fish swimming near the surface, he carefully maneuvered his boat and drove the fish into shallow water where he was able to capture it with his hands. The specimen was a 944-mm. dolphin. In recent years dolphins have been reported from Cape Cod and Nova Scotia (Schuck, 1951, Copeia (1): 171), but this is the first record in Maine waters.

Zenopsis ocellatus (Storer); John Dory.—During the last week of May, 1952, the otter trawler, Theresa R., while fishing for groundfish, caught a 201-mm. John Dory in 75 to 85 fathoms of water 18 to 20 miles east of Mount Desert Rock, Maine. The specimen was presented to us by Captain Reuben S. Doughty and Harold Paulson of Portland.

Urophycis tenuis (Mitchill); mud hake.—On February 1, 1952, I examined 100 mud hake at Wilson's Beach, Campobello Island, New Brunswick, and found 2 specimens exceeding the maximum size previously reported (Scattergood, 1952, Copeia (3): 206). One was 53 inches long and weighed 47¼ pounds; the other was 52 inches and 46 pounds. The fish were caught by line trawlers off Beaver Harbor, N. B., in the Bay of Fundy. (The name white hake is used by the U. S. Fish and Wildlife Service for this species, and is preferred by the author.)

Paralichthys dentatus (Linnaeus); summer flounder.—On June 8, 1952, Robert W. Davis of the Maine Department of Sea and Shore Fisheries caught a 411-mm. summer flounder in a fyke net set in 4 fathoms of water at Boothbay Harbor, Maine. This was an unusual capture, for Ginsburg (1952, U. S. Fish and Wildl. Serv., Fish. Bull. 71: 318) reported that, according to the data extant, the summer flounder does not occur north of Cape Cod.—Leslie W. Scattergood, *U. S. Fish and Wildlife Service, Boothbay Harbor, Maine.*

Reviews and Comments

FUNDAMENTALS OF LIMNOLOGY. By Franz Ruttner, 2nd edition, 1952; English translation by D. G. Frey and F. E. J. Fry. University of Toronto Press, Toronto, 1953: XI + 242 pp., 51 text figs. $6.50.—The present volume is a translation of the manuscript of the second edition of Ruttner's textbook. By combining their efforts and obtaining the recent revision, the translators now offer a well prepared and up-to-date text for the English-speaking classroom.

Ruttner considers a comprehensive knowledge of the environment to be essential to an understanding of biological phenomena in a body of water. Thus, the central theme of the book is the environment, and approximately the first half of the volume is devoted to the subject "Water As An Environment." Here is to be found a clear and concise statement of the physical basis of environmental conditions in inland waters, well illustrated with examples taken largely from the author's extensive studies of Alpine lakes of the Austrian Alps and of tropical lakes of Java and Sumatra. Particularly satisfying is the treatment of the fate of incident solar radiation in lakes. Here the author follows the various heat transfers that occur in both temperate and tropical lakes in a very clear yet fundamental way so as to leave few questions to be answered in the classroom regarding such subjects as the annual temperature cycle and thermal stratification. No attempt is made to follow a rigid thermal classification of lakes, as has been done in American textbooks. Forel's system is considered to be somewhat too broad in the light of recent findings.

Under the heading "Dissolved Substances and Their Transformation," attention is given chiefly to substances active in the biochemical cycles of inland lakes. Fundamentals of the carbon dioxide cycle and its relation to animal and plant metabolism are presented with a minimum of technical detail and data. Simple laboratory experiments are

described which effectively illustrate critical parts of this cycle. Use of the oxygen curve as an index to productivity is considered but does not receive the emphasis given by European limnologists two decades ago. The interesting relationships of iron and manganese receive a liberal share of attention. However, the transformations of nitrogen, phosphorus and organic substances are summarized rather briefly. Material relating to chemical transformations taking place in the bottom mud and at the mud-water interface is to be found in the second section of the book under "The Communities of the Ooze."

"Biotic Communities," the second major section of the book, deals rather briefly with selected freshwater communities. In the discussion of plankton, major emphasis is placed upon problems of spatial and temporal distribution of the biota and upon problems of production. The interesting discussion of the interaction of light and temperature in determining the seasonal species composition of plankton, based largely on Findenegg's work on the Carinthian lakes, is evidence that many puzzling problems of the temporal and spatial distribution of plankton can be solved if given careful analysis. The section titled "Communities of the Aufwuchs" (attached organisms and included free-living forms) presents recent findings concerning an ecosystem that has received little attention in this country. Running water and bog communities are treated briefly but effectively.

A somewhat more liberal use of illustrative material would add to the book's value as a text. Also it is unfortunate that many paragraphs of the text have been set in 10 point type while the remainder is in 9 point. This de-emphasizes some material of considerable importance. A glossary of technical expressions has been included, and the translators have supplied a brief table of the English equivalents used in the translation of German terms which have no accepted English forms.

Ruttner's book succeeds admirably in presenting the core of fundamentals, together with an interesting background of well selected observations and data, in a small volume. It should prove stimulating to both the student and the trained biologist. Most certainly it will serve to refocus emphasis and to direct attention toward topics as yet pursued very little in this country.—FRANK F. HOOPER, *Institute for Fisheries Research, University Museums Annex, Ann Arbor, Michigan.*

ZOOGEOGRAPHY OF THE SEA. By Sven Ekman. Sidgwick and Jackson, London, 1953, handled in the U. S. by The Macmillan Co., N. Y.: xiv + 417, 121 figs. $6.50.—The publication of the revised, English edition of this work is a very welcome event for all marine zoologists, particularly for those unfamiliar with the out-of-print and rather sparsely distributed German text of 1935 (reviewed in COPEIA, 1937: 77, by C. L. Hubbs). The present edition is far more than a translation of the earlier work, as evidenced by Ekman's reference to over 150 papers published after 1935.

Though there has been a general updating of each of the original sections, the ground plan of the German edition has been retained. As before, the primary divisions are the shelf, benthal deep-sea, epipelagic, and bathypelagic faunas, and the treatment of each of these is on a regional basis. The amount of space devoted to each major topic also approximates that of the earlier edition. In some "revised" works such conservatism might be attributed to laziness on the part of the reviser, but with Ekman's book I believe that the lack of basic change is due to the excellence of the original organization. Ekman's basic postulates, such as the existence of a major faunal barrier for shallow-water tropical animals in the eastern Pacific, have stood the test of time. Other valuable and enduring concepts upon which the book is constructed are that faunal regions should be based on the animals themselves, that the boundary lines between various regions are not all correlated with the same physical feature, and that the nature of present faunas is indissolubly bound up with their past histories.

To me the most serious defect of the book is the tendency to evaluate all systematic papers at their face value. Ichthyologists may be somewhat horrified at the reliance Ekman (who is not an ichthyologist) places on the conclusions reached in the less trustworthy of fish publications. Fortunately, few basic errors have resulted. A stumbling block to casual readers (for whom the book was not primarily written) may be the long list of examples that Ekman provides to bulwark each of his conclusions. Of overlooked major references I find very few. Such as there are seem to fall chiefly into two categories: very recent papers published while Ekman's book was undergoing translation, and works written in Russian.

Whereas the format of the earlier edition bordered on the lavish, that of the present text is merely satisfactory. In the revised work the paper is soft rather than glossy and does not take the illustrations quite so well, and the number of figures has been reduced by nearly half. Nevertheless, it cannot be said that the English edition is either unsatisfactorily or insufficiently illustrated. In short, savings in cost of publication seem to have been judiciously made. The translation is good, and typographical errors, though present, are not abundant.—WILLIAM A. GOSLINE, *University of Hawaii, Honolulu, T. H.*

BETWEEN PACIFIC TIDES. By Edward F. Ricketts and Jack Calvin. Third Edition, revised

by Joel W. Hedgpeth. Stanford Univ. Press, Stanford, Calif., 1952: xiii + 502, 134 numbered figs., 46 pls., col. frontis., 1 map. $6.00.—This classic contribution to the littoral marine fauna of the Pacific Coast was first published in 1939 (see review in COPEIA, 1939 (4): 238). The present edition has been greatly improved by Hedgpeth's stimulating chapter on Intertidal Zonation and by his presentation of a much expanded index. This includes numerous references, carefully chosen, and forms an annotated systematic index and bibliography. Also adding to the improvement are some very fine, useful new photographs and several dozen new drawings. The nomenclature has been brought up to date.

This book presents a detailed account of the habits and hatitat of some 500 of the conspicuous seashore invertebrates between Sitka, Alaska, and northern México. The animals are grouped according to their typical habitat whether rocky shore, sand flat, or wharf piling. Life history and physiology, community relationships, and the effect of wave shock and tidal level are some of the factors described by the authors. The present revision, incorporating results of wartime research, adds 138 pages. The thinner paper is superior to the previous editions as it lends itself better to the line drawings and reduces the bulkiness of the book. While Dr. Hedgpeth has given the book more scientific backbone, the warmth and spirit of curiosity that permeated the original text have been retained. Ichthyologists will find a convenient index on pages 469–70 to the dozen fishes mentioned throughout the text, and also a brief list of references to recent papers on Pacific tidepool fishes. This book is highly recommended to all those interested in the fascinating world of seashore life.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

THE BIOCHEMISTRY OF FISH. Ed. by R. T. Williams. Biochemical Society Symposia No. 6 Cambridge Univ. Press, N. Y., 1951: 1–105, 14 figs. $2.75.—This is a series of papers by seven contributors given at a sympsoium of the British Biochemical Society held in 1950 at the University of Liverpool. The symposium was organized and edited by R. T. Williams with an introduction by R. A. Morton and a contributing note by A. Wormall. The titles of the seven papers, with authors in parentheses, are as follows: Some Comparative Aspects of the Biochemistry of Fish (E. Baldwin); The Proteins of Fish (G. Hamoir); The Chemistry and Metabolism of the Nitrogenous Extractives in Fish (J. M. Shewan); The Chemistry and Metabolism of Fats in Fish (J. A. Lovern); Carotenoids in Fish (T. W. Goodwin); Bile Salts of Fish (G. A. D. Haslewood); and Economic Aspects of the Utilization of Fish (C. L. Cutting). The contributors are from various institutions in England, Scotland, and Belgium.

The search for rich sources of vitamins A and D has stimulated studies on the nutritional value of fishes so that the biochemistry of these animals is attracting more and more attention. This is a subject of wide scope with applications of great economic interest.

The total annual world consumption of fish protein approximates one million tons and in much of the Orient it comprises the major component of protein in the diet. In his article, Cutting points out that the fishing industry is faced with the technical problems of preservation and utilization and with the biological problem of overfishing. This is the only paper of the group that stresses practical applications and should be brought to the attention of fishery biologists.

A summary of knowledge on varied phases of the subject is brought out in this symposium and is worthy of the attention of those seriously interested in all aspects of ichthyology. Interesting biochemical differences, associated with contrasting physiological adaptations, are to be seen, for example, between the freshwater and the marine fishes; and euryhaline species pose a peculiar and fascinating problem, both to the biochemist and the physiologist. The problem of biochemical relationship has been stressed throughout the symposium. A considerable amount of the Old World literature is brought into these discussions and this enhances their value for the American reader.—ROBERT RUSH MILLER.

FRESHWATER TROPICAL AQUARIUM FISHES. By G. F. Hervey and J. Hems. The Batchworth Press, London, 1952: xiv + 425, figs. 1–87, 32 pls. (8 in color). 40s. (= approx. $5.70).—This is an attempt, by a zoologist and an aquarist, to present an encyclopedic survey of a very popular subject. No one or two workers, however, can speak with authority on so broad a field as that of tropical aquarium fishes. The volume is said to include descriptions of some 500 different kinds.

The first 110 pages cover history, aquarium building, stocking and maintenance, foods and feeding, diseases and parasites, breeding, and showing. This is a very informative, well planned and useful section. The next 276 pages consist of a catalogue of freshwater fishes which is followed by 2 appendices (making aquaria, and the tropical marine aquarium), an outline classification (after Schultz and Stern), a bibliography (which fails to include *The Aquarium Journal*), and three indices (general, popular names, and scientific names). Many of the line drawings and some of the colored plates and half tones leave much to be desired, for recognition

of the species labelled is often difficult even for one familiar with them.

Had the authors asked for advice from the ichthyologists of the British Museum (Natural History), many errors in fish identification and classification, as well as stated ranges, could have been avoided. A few of the more glaring mistakes noted by this reviewer follow. The catfishes of the Old World (p. 229) belong to more than a dozen families, of which the Siluridae is one of the lesser groups. Halfbeaks (p. 232) are a conspicuous element of the New World as well as the Old World fish fauna. The Eurasian cyprinodontid *Aphanius* is said to inhabit the United States, Cuba and México (p. 235). I know of no salt water and few brackish water records of *Fundulus chrysotus* in nature (p. 256). *Alfaro amazonus* (p. 273) was long ago synonymized with *A. cultratus* and is known only from Nicaragua to Panamá (I consider *Furcipenis* to be a distinct genus). The firmly established but thoroughly disproved belief that *Periophthalmus* breathes through its tail is repeated once again (p. 381).

Despite these criticisms, there is much useful and interesting information in this book, its price is reasonable, and if used with caution it provides a valuable reference book on tropical fishes.—ROBERT RUSH MILLER.

AQUARIUMS. By Anthony Evans. Dover Publications, Inc., N. Y., 1952: 115 pp., 26 figs., 48 photos. $.60 (paperbound), $1.50 (clothbound).—The editor of *The Aquarist and Pondkeeper* has produced a most useful, concise booklet admirably suited for the beginning aquarium-keeper. It is authentically and well written, the nomenclature is modern, and the illustrations are good. It includes chapters on fish-keeping equipment, aquarium management, water plants, garden pond-making (including stocking and maintenance), keeping of coldwater and tropical fishes, fish foods and feeding, breeding, troubles (diseases, cloudy water, etc.), a brief description of how to keep a saltwater aquarium, and closes with a good index. There are short lists of general fish books, aquarium fish books, and magazines devoted to home aquaria and garden ponds. The format is 5 × 7¼ inches and the printing is very readable. This booklet is well worth its purchase price for the increasing horde of home fish-keepers.—ROBERT RUSH MILLER.

EDITORIAL NOTES AND NEWS

Amateur herpetologists

THE Amateur Herpetologist's Exchange proposes a new publication in the field of herpetology. It will be issued quarterly and will be concerned with and devoted to the amateur herpetologist. Membership in the AHE will include an identification certificate, one year's subscription to the journal (beginning January, 1954), full advertising rights, free distribution of herpetological literature, etc. The subscription and membership fee is one dollar ($1.00) per year. Further information may be obtained by writing directly to The Amateur Herpetologist's Exchange, 729 North Shore Drive, South Haven, Michigan.

News Notes

DR. ERNEST A. LACHNER, of the U. S. National Museum, received the annual Award for Scientific Achievement in the Biological Sciences of the Washington Academy of Sciences on March 19, 1953. The award was made in recognition of his achievements in ichthyology, especially in the taxonomy of the Apogonidae and Mullidae.

MR. JORGE CARRANZA, of the Comisión para el Fomento de la Piscicultura Rural of México, spent 18 months (in 1952–53) in the United States on a Rockefeller Foundation grant to study methods of freshwater pondfish culture. A third of this time was devoted to studies at the Alabama Polytechnic Institute, followed by visits to Washington, D. C., and New York, and a full scholastic year was spent in the School of Natural Resources at the University of Michigan, obtaining an M.A. degree and working for the Ph.D. In addition to course work, he undertook systematic studies of a group of cichlid fishes native to Middle America. He has been appointed Director of the Pátzcuaro Limnological Station, Pátzcuaro, Michoacán, México.

MR. FRANK T. KNAPP, formerly at Texas A. & M. College, is now Chief Marine Biologist at the Marine Laboratory, Box 283, Brunswick, Georgia.

MR. GORDON E. HALL, formerly associated with the Oklahoma Game and Fish Department, is now with the Fishery Research Laboratory, Box 14, North Campus, Norman, Oklahoma.

The University of Texas has received a substantial research grant from the National Science Foundation to carry out a study of interbreeding of vertebrate populations in relation to geographic differentiation and speciation. DR. W. FRANK BLAIR will direct and carry on research on anuran amphibians, and DR. CLARK HUBBS will be in charge of the experimental work with oviparous freshwater fishes. Investigation of the factors affecting gene exchange in these animals will permit comparison of the effectiveness of the different isolating mechanisms that have evolved in conjunction with the very different modes of reproduction. The duration of the project is estimated at three years.

DR. LESTER R. ARONSON, Chairman of the Department of Animal Behavior of The American Museum of Natural History, is on a nine-month expedition to Nigeria to study the reproductive behavior and ecology of the cichlid fish *Tilapia macrocephala*. The work is being carried out on a Fulbright Research Scholarship. DR. ARONSON will correlate data obtained during 15 years of laboratory study with findings on the species in its native habitat.

DR. REEVE M. BAILEY has received a grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan to study the faunal affinities of the fishes of the Green River system in Kentucky and Tennessee.

DR. ROBERT R. MILLER has also received a grant from the same source for a study of speciation in the genus *Poeciliopsis*. Field work will be conducted in northwestern México, with emphasis on ecology, and will be supplemented by breeding experiments in aquaria and by analysis of preserved specimens.

RICHARD HAVEN BACKUS completed the Ph.D. in Cornell in May, 1953. His thesis is entitled "The Marine and Freshwater Fishes of Labrador" and includes data from the extensive collections made by the BLUE DOLPHIN Labrador Expedition under the direction of COMMANDER DAVID C. NUTT. DR. BACKUS is now employed as biologist by the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

DR. ROLAND L. WIGLEY, recently aquatic biologist of the New Jersey Game and Fish Commission, is now employed by the U. S. Fish and Wildlife Service as fishery research biologist at the Woods Hole, Massachusetts, laboratory.

The Southeastern Division of the ASIH will hold its annual meeting in Athens, Georgia, on October 9 and 10 this fall.

Correction In COPEIA, 1953, No. 2, page 94, left column, line 16 should read as follows: "is forked opposite the 16th. Sulcus spermaticus forked opposite the 8th caudal; the forks are".

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

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